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Polymere

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(56) References cited:

EP-A- 0 031 305	EP-A- 0 124 782
WO-A-86/00626	DE-A- 1 918 023
DE-A- 2 944 092	DE-A- 2 945 549
DE-A- 3 311 752	DE-B- 1 645 232
DE-B- 2 009 433	DE-B- 2 236 513
US-A- 4 429 099	

• Rauch-Puntigam et al. "Acryl- und  
Methacrylverbindungen" Springer Verlag,  
Berlin, 1967, p. 368

**EP 0 448 224 B2**

## Description

[0001] This invention relates to certain novel star co-polymers, their preparation and use in coating compositions.

[0002] The co-polymers of the present invention have an idealised structure that can be regarded as consisting of a number of arm that radiate from a central point. Polymers having such geometry are referred to colloquially as star polymers or polymers with star geometry.

[0003] Our co-pending European patent publication EP-A-449413 discloses a star co-polymer comprising a hub portion from which radiate from 3 to 8 arms, where the hub portion is the residue of a tri- to octafunctional thiol and each arm is an addition polymer comprising structural units and functional units where the functional units contain hydrolysable group-bearing silicon atoms.

[0004] DE-A-2944092 discloses polymers formed from acrylic and thioether-containing mercapto monomers that are for use in the production of a photographic silver halide emulsion. The polymers are not of star configuration.

[0005] EP-A-31305 discloses polymer compositions formed by actinic radiation-induced or free-radical polymerization of acryloyloxy and aromatic allyl-containing compounds including at least three double bonds and a polymercaptan.

The polymer compositions are not of star configuration and are for use in the production of surface coatings for printing plates and printing circuits, adhesive bonds, and of reinforced composites.

[0006] We have now discovered a class of star polymers that have benefits in the manufacture of coating compositions.

[0007] According to the present invention there is provided a star co-polymer having a weight average molecular weight of from 3 000 to 30 000 inclusive and having a hub portion from which radiate from 3 to 8 arms where the hub portion is the residue of a tri-functional to octa-functional thiol ester, formed from a tri-functional to octa-functional alcohol and thio  $C_{2-6}$  alkanolic acid, and each arm is an addition polymer comprising structural units and functional units where the functional units, but not the structural units, include crosslinking substituents and are mutually compatible in that the crosslinking substituents are capable of undergoing a crosslinking reaction with a crosslinking agent or the same or a complementary substituent in functional units in another molecule of the same polymer, and optionally compatible auxiliary functional units that contain wetting groups.

[0008] The advantages of these polymers in coating compositions can at least in part depend upon the particular functional units employed and the crosslinking reaction they undergo. One advantage seen in particular with hydroxy functional star polymers and isocyanate crosslinking agents, is that compositions based on them have improved pot lives and gel times compared with compositions based on corresponding linear polymers. Further, a primer composition based on such a star polymer has improved sandability as compared to one based upon a commercial standard. Also and particularly at relatively high functionality a star polymer composition is, as compared with a commercial standard based on a linear polymer, relatively stable to ultra violet degradation. Further waterborne compositions based on allyl functional and hydroxy functional star polymers display viscosities much lower than would be expected from their molecular weights whilst showing relatively improved film performance.

[0009] The co-polymers of this invention have a total weight average molecular weight of at least 3,000. In practice, the molecular weight will not be more than 150,000. For example the molecular weight can be 3,000 to 30,000, particularly 3,000 to 15,000 the molecular weight is 5,000 to 10,000. The term 'molecular weight' here means the apparent total weight average molecular weight. Apparent molecular weight is measured by the gel permeation chromatography method described in Gel Chromatography: Theory, Methodology and Application, T Kremmer and L Boross, Wiley Interscience 1979.

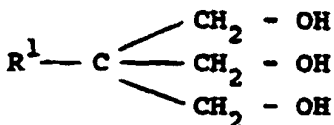
[0010] The co-polymers of the invention have a hub portion that is the residue of a trifunctional to octafunctional thiol. In an idealised structure, an addition polymer arm extends from each thio moiety in the hub, hence the three to eight arms.

[0011] Preferably the hub is the residue of a trifunctional, tetrafunctional or hexafunctional thiol especially a tetra or hexafunctional thiol.

[0012] The trifunctional to octafunctional thiol can be aromatic or aliphatic. Examples of aromatic thiols are benzene-1,3,5-trithiol, 3,4,8,9-tetramercaptotetrafulvalene and 7-methyltrithiouric acid.

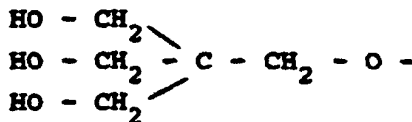
[0013] Preferably, the thiol residue is the residue of an ester formed from a trifunctional to octafunctional alcohol and a thio- $C_{2-6}$  alkanolic acid.

[0014] Examples of suitable alcohols are glycerol, sorbitol and especially alcohols having the general formula (1):-



(1)

where R<sup>1</sup> is hydrogen, C<sub>1-4</sub> alkyl or hydroxy-C<sub>1-4</sub> alkyl, (especially methyl, ethyl, hydroxymethyl or hydroxyethyl) or a group of formula (2):-



(2)

[0015] Examples of mercapto-C<sub>2-6</sub>-alkanoic acids are 2-mercaptoacetic acid, 2-mercaptopropionic acid, 3-mercaptopropionic acid, 4-mercaptopbutyric acid, 5-mercaptopentanoic acid and 6-mercaptohexanoic acid. Preferably the mercaptoalkanoic acid is 2-mercaptoacetic or 3-mercaptopropionic acid.

[0016] Each arm of the star co-polymer is made up of structural units, functional units that are mutually compatible and include crosslinking substituents capable of undergoing a crosslinking reaction with a crosslinking agent or with the same or a complementary substituent in functional units in another molecule of the same polymer and optionally compatible auxiliary functional units containing wetting groups. As in conventional acrylic polymers, the distribution of such units is random.

[0017] The total average mole percentage of functional units and auxiliary functional units in the arms is from 10% to 70%, for example 25% to 50% or 60% to 70% particularly 30% to 40% of the arm. The average mole percentage of functional units in each arm is calculated from the mole percentage of total monomers making up the arms that is represented by the monomers that will provide the functional units.

[0018] The functional units that are selected for any particular polymer are chosen so as to be mutually compatible. This means that the substituents tend to undergo inter-molecular crosslinking reactions with a crosslinking agent or with the same or complementary substituents in functional units in another molecule in preference to intra-molecular reactions with crosslinking substituents in functional units in the same molecule.

[0019] Examples of crosslinking substituents are hydroxyl, carboxyl, isocyanate, blocked isocyanate, epoxy, allyloxyester and 2-hydroxy-3-allyloxy propyl ester groups.

[0020] Where the functional units contain the same crosslinking group, it is selected such that the crosslinking reaction requires a crosslinking agent or where self crosslinking takes place between different molecules in the same polymer, that the crosslinking reaction requires triggering for example by a catalyst.

[0021] So for example hydroxyl group-containing polymers require for example an isocyanate-containing cross-linking agent. 2-Hydroxy-3-allyloxypropyl ester groups generally require a cobalt catalyst for cross-linking with each other.

[0022] Where the polymer has two or more different types of functional unit or contains functional units and auxiliary functional units, the different crosslinking groups or the crosslinking groups and the wetting groups are chosen so that crosslinking is inter-molecular rather than intra-molecular. For example, where there are two such different types of functional units one type can contain hydroxy groups and the other carboxy groups, or hydroxy groups and blocked isocyanate groups, or hydroxy groups and epoxy groups, or carboxyl groups or salts thereof and allyl or 2-hydroxy-3-allyloxy propyl ester groups.

[0023] Examples of wetting groups for auxiliary functional units are 4-nitrobenzoyloxy and 4-aminobenzoyloxy and its acid addition salt derivatives. Examples of acid addition salts are hydrohalide salts especially hydrochloride or organic acid salts for example an acetic acid salt.

[0024] The functional units can be derived from hydroxy, carboxy, isocyanate, blocked isocyanate or epoxy group-containing ethylenic monomers, or from the reaction of a carboxyl group-containing unit with allyl alcohol or 1-allyoxy-2,3-epoxy propane.

[0025] Where the polymer contains carboxyl groups or salts thereof and 2-hydroxy-3-allyloxy propyl ester groups preferably the molar ratio of free acid or salt group to ester group is from 1 to 3 to 1 to 9 in particular 1 to 5.6 to 1 to 7.33. The ratio 1 to 3 means that 75 mole % of the carboxyl groups are esterified. The ratio 1 to 5.6 means 85% of the carboxyl groups are esterified, the ratio 1 to 7.33 means that 88% of the carboxyl groups are esterified and a ratio of

1 to 9 means that 90% of the carboxyl groups are esterified.

[0026] The carboxyl groups can form salts for example alkali metal, alkaline earth metal and ammonium salts especially lithium and sodium salts.

[0027] Where the co-polymer contains more than one functional unit, the unit present in the largest amount will not usually exceed 97 mole % of the total of the functional units. Usually it will not exceed 90 mole % of the total.

[0028] Where the co-polymer contains auxiliary functional units, the auxiliary functional unit will not be less than 0.5 or 1.3 mole % of the total functional units. Typically it will be 0.5 to 5 mole % especially 1 to 2 mole %.

[0029] Examples of hydroxyl group-containing monomers are allyl alcohol and esters of formula (3):-



where

R<sup>1</sup> is hydrogen or methyl and R<sup>2</sup> is C<sub>2-6</sub> alkanediyl especially ethane-1,2-diyl, propane-1,3-diyl and butane-1,4-diyl.

[0030] Examples of carboxy group-containing monomers are acrylic, methacrylic and maleic acid and maleic anhydride.

[0031] Examples of isocyanato group-containing monomers are 2-(3-isopropenylphenyl)-2-isocyanatopropane and esters of formula (4):-



where

R<sup>2</sup> and R<sup>3</sup> are as defined with reference to formula (3) especially where R<sup>1</sup> is methyl and R<sup>2</sup> is ethane-1,2-diyl.

[0032] Examples of blocked isocyanate group-containing monomers of formula (4) are monomers where the isocyanate group has been blocked with an alkanol, especially a C<sub>1-10</sub> alkanol, an alkoxyalkanol especially a C<sub>1-3</sub> alkoxy C<sub>1-3</sub> alkanol, an hydroxy ester, a keto ester, an oxime, a ketoxime, an optionally substituted phenol, a lactam (including cyclic lactams) and N-hydroxy imides especially cyclic N-hydroxy imides. Blocking groups of this type are described in Preparation, Polymerisation and Evaluation of Blocked Isocyanato-ethyl Methacrylate H.G Fravel Jr et al Ind. Eng. Chem. Prod. Res. Dev. 1984 23 586.

[0033] Examples of epoxy group-containing monomers are glycidyl acrylate and glycidyl methacrylate.

[0034] Examples of structural units are units derived from ethylenically unsaturated monomers in particular C<sub>1-8</sub> alkyl esters of acrylic and methacrylic acids, vinyl C<sub>2-6</sub> alkanoates and styrene and its C<sub>1-4</sub> alkyl analogues.

[0035] Examples of C<sub>1-8</sub> alkyl esters of acrylic and methacrylic acids are methyl methacrylate, ethyl methacrylate, propyl methacrylate, pentyl methacrylate, hexyl methacrylate, octyl methacrylate, ethyl acrylate, propyl acrylate, butyl acrylate, pentyl acrylate, hexyl acrylate, octyl acrylate and 2-ethylhexyl acrylate.

[0036] Examples of vinyl C<sub>2-6</sub> alkanoate esters are vinyl acetate, vinyl propionate and vinyl butanoate.

[0037] Examples of styrene and its C<sub>1-4</sub> alkyl analogues are 4-methylstyrene and 4-ethylstyrene.

[0038] Preferably the structural units are derived from methyl methacrylate, ethyl methacrylate butyl methacrylate and butyl acrylate.

[0039] The identity and proportion of monomers directly affects the glass transition temperature (T<sub>g</sub>) of the film forming polymer, therefore monomers and their proportions are selected to achieve a calculated glass transition temperature which is appropriate to the end use to which the film forming polymers are to be put. The T<sub>g</sub> is calculated using the Fox equation as described in Polymer Science, V R Growariker, N V Viswanathan and Jayadev Greedhar 170, John Wiley and Sons (1986).

[0040] The identity and proportion of the monomers from which the functional units are derived is limited as previously discussed. Variations in T<sub>g</sub> are therefore achieved by selection of the appropriate proportions of monomers providing structural units.

[0041] Co-polymers of the invention can have a wide range of T<sub>g</sub>'s for example -5 to +100°C. Co-polymers having a T<sub>g</sub> in the range of -5 to 55°C are particularly useful in paints for respraying motor vehicles. Co-polymers having a T<sub>g</sub> in the range +45 to 100°C are particularly useful in the preparation of paints for painting motor vehicles especially in a vehicle manufacturing line.

[0042] The co-polymers of the present invention can be prepared by a process which comprises reacting together at moderate to elevated temperatures, a tri- to octa-functional thiol chain transfer agent with ethylenically unsaturated monomers that polymerise to form structural units, ethylenically unsaturated monomers that polymerise to form functional units and optionally ethylenically unsaturated monomers that polymerise to form auxiliary functional units thereby

forming a co-polymer and optionally thereafter, where a salt or ester is required, salifying or co-reacting a polymer so formed containing functional units having carboxyl groups with allyl alcohol or 1-allyloxy-2,3-epoxypropane or optionally reacting a co-polymer so formed containing functional units having epoxy groups with 4-nitrobenzoic acid or 4-aminobenzoic acid and optionally converting the product so obtained into an acid addition salt.

[0043] The reaction is carried out in the presence of an initiator for the free radical reaction for example, a per ester for example t-butyl perbenzoate, t-butyl per-2-ethyl hexanoate or azobisisobutyronitrile.

[0044] Preferably the reaction is carried out in such a way that the molecular weight distribution of the polymer product is small. This can be achieved by producing a high radical flux at the beginning of reaction. This in turn is achieved either by using a fast initiator, that is one that produces a large number of free radicals very quickly, or a relatively slow initiator, and adding monomer to an excess of the initiator.

[0045] The particular process employed depends on the monomers to be polymerised and the properties looked for in the end product. The precise combination of monomer and initiator can be determined in any particular case by routine experimentation.

[0046] The polymerisation reaction is carried out at moderate to elevated temperature. The precise temperature depends upon the specific initiator employed and the monomers to be polymerised. Usually the reaction is carried out at from 70 to 170°C especially from 100 to 140°C.

[0047] The post-esterification and epoxide ring opening can be carried out at moderate temperatures for example ambient temperature optionally in the presence of a catalyst.

[0048] The polymerisation reaction and the post esterification reaction are carried out in the presence of a non-interfering solvent or diluant for example a high boiling aromatic hydrocarbon, particularly xylene or a high boiling hydrocarbon solvent blend, for example "Solvesso".

[0049] The salification steps can be carried out by standard procedures for example by contacting the polymer containing free acid groups with a base, or the polymer containing free amino with an acid in a liquid medium in which the base or acid is soluble and the polymer is at least partially soluble.

[0050] The aromatic thiols specifically referred to above, the alcohols of formula (1), vinyl monomers of formula (3), acrylates and methacrylates of formula (4) are known, or can be made by analogy with known processes.

[0051] In use, the polymers of this invention are formulated with a volatile liquid diluant or carrier into coating compositions.

[0052] According to the present invention there is also provided a coating composition comprising a star co-polymer and a liquid diluent or carrier characterised in that the star co-polymer has a hub portion from which radiate from 3 to 8 arms where the hub portion is the residue of a tri-functional to octa-functional thiol ester, formed from a tri-functional to octa-functional alcohol and thio C<sub>2-6</sub> alkanic acid, and each arm is an addition polymer comprising structural units and functional units where the functional units, but not the structural units, include crosslinking substituents and are mutually compatible in that the crosslinking substituents are capable of undergoing a crosslinking reaction, with either a crosslinking agent, in which case the composition also comprises a crosslinking agent, or the same or a complementary substituent in functional units in another molecule of the same polymer, and optionally compatible auxiliary functional units that contain wetting groups.

[0053] Examples of liquid carriers are aliphatic hydrocarbons, aromatic hydrocarbons, halogenated hydrocarbons, alcohols, ketones, esters, ethers alcohols and water.

[0054] The amount of the liquid carrier can be varied depending on the molecular weight or composition of the polymer so that the resulting composition is of an appropriate viscosity for the method of application chosen.

[0055] The compositions also comprise crosslinking agents. The crosslinking agent chosen in any particular case depends upon the functional units in the polymer.

[0056] Where the functional units in the co-polymer contain an hydroxyl group, the crosslinking agent can be a di- or multifunctional isocyanate, a melamine formaldehyde resin or a glycoluril. Glycolurils are also effective as crosslinking agents for polymers where the functional unit contains carboxyl groups.

[0057] Examples of simple di- and multifunctional isocyanates are alkane diisocyanates of formula (5):-



where  $n$  is from 2 to 8. In particular  $n$  is 4 to 6 especially 6.

[0058] An example of a simple cycloalkanediisocyanate is isophoronediiisocyanate.

[0059] Examples of simple aromatic di-isocyanates are toluene-2,4-diisocyanate and 4,4-diphenylmethane diisocyanate.

[0060] Complex multi-functional oligomeric isocyanates are reaction products of di- and polyols with the difunctional isocyanates described above.

\* = Trade Mark

[0061] Examples of diols and polyols are ethylene glycol, propyleneglycol, trimethylolpropane and pentaerythritol.

[0062] Optionally the composition also comprises a catalyst for the crosslinking reaction. For example the catalyst can be an organotin compound for example dibutyltin dilaurate.

[0063] These isocyanate crosslinkers are known or can be made by analogy with known methods. Many are available under the brand name 'Desmodur'.

[0064] Melamine formaldehyde resins are commercially available under the trade name 'Cymel'.

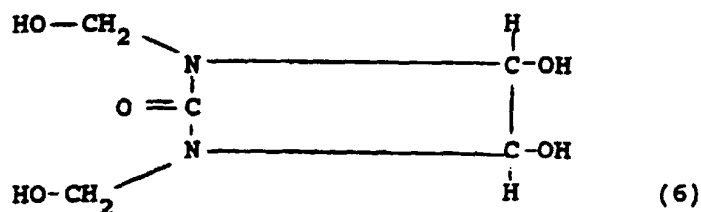
[0065] Where the functional units in the co-polymer contain isocyanate groups then the crosslinker can be a di- or multifunctional alcohol.

[0066] Examples of simple di- and multi-functional alcohols are ethylene glycol, propylene glycol, trimethylol propane and pentaerythritol.

[0067] Such compositions can also comprise a catalyst for the cross linking reaction. The catalyst can be an organotin compound for example dibutyltin dilaurate.

[0068] Glycolurils (also called acetylene ureas) and their preparation is described in US Patent No. 4064191. They are prepared by reacting two moles of urea with one mole of glyoxal. The glycoluril so obtained can optionally bear a C<sub>1-6</sub> alkyl substituent (this is introduced by selection of appropriate starting materials) or can be methylolated partially or fully by reaction with from 1 to 4 moles of formaldehyde.

[0069] Examples of glycolurils disclosed in US Patent No. 4064191 are tetramethylol glycoluril, tetrabutoxymethyl glycoluril, partially methylolated glycoluril, tetramethoxymethyl glycoluril, and dimethoxydiethoxy glycoluril. A particular group of glycoluril derivatives consists of mono- and dimethylether of dimethylol glycoluril, the trimethylether of tetramethylol glycoluril, the tetramethylether of tetramethylol glycoluril, tetrakisethoxymethyl glycoluril tetrakispropoxymethyl glycoluril, tetrakisbutoxymethyl glycoluril, tetrakisamyloxymethyl glycoluril and tetrakisheoxymethyl glycoluril. Another glycoluril is dimethylol dihydroxyl ethylene urea. Its chemical structure is thought to be as shown in formula (6).



[0070] The cross-linking reaction between the hydroxy polymer and the glycoluril can be catalysed by an acid catalyst for example toluene sulphonic acid.

[0071] Glycolurils are particularly useful as cross-linkers for water-borne coating compositions.

[0072] Where the functional unit contains an isocyanate group or epoxy group, the crosslinking agent is a simple mono-primary amine or a simple di- or multi-functional amine.

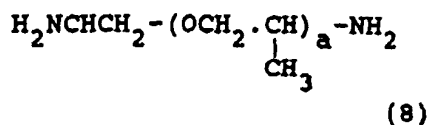
[0073] Examples of simple mono primary amines are C<sub>2-8</sub> alkyl amines, in particular ethylamine, propylamine, butylamine and hexylamine.

[0074] Examples of simple di-amines are amines of formula (7):-



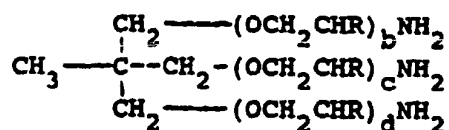
where  $m$  is from 2 to 8, especially 4 to 6. A particular diamine is 1,6-diaminohexane.

[0075] Examples of complex diamines are amine-terminated polypropylene glycols of formula (8):-



where  $\underline{a}$  is from 2 to 6.

[0076] Examples of complex triamines are of general formula (9):-



(9)

where R is hydrogen or C<sub>1-6</sub>alkyl, for example methyl ethyl or propyl, and  $\underline{b}$ ,  $\underline{c}$  and  $\underline{d}$  are integers such that their sum is from 3 to 30.

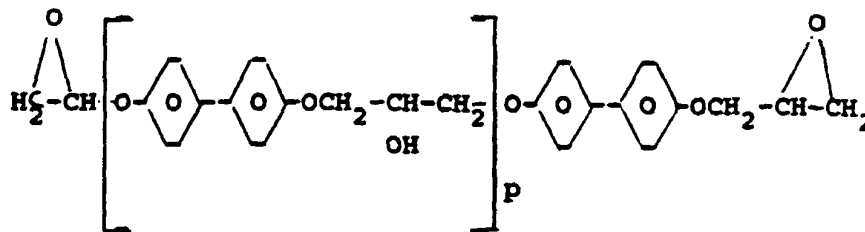
[0077] Amines of formula (8) and (9) are commercially available under the trade mark 'Jeffamine'.

[0078] Where the functional units in the co-polymer contain allyl ester groups, crosslinking takes place by free radical polymerisation. The compositions can contain a free radical initiator. Examples of suitable free radical initiators are peroxides especially benzoyl peroxide.

[0079] Where the functional units in the co-polymer contain 2-hydroxy-3-allyloxypropyl ester groups, crosslinking takes place by autoxidation in air in the presence of a cobalt catalyst for example cobalt octoate or cobalt naphthenate.

[0080] Where the functional unit contains a carboxyl group, the crosslinking agent can be a di- or multifunctional epoxide.

[0081] Examples of polyepoxides include polyglycidylethers of polyphenols, especially those having an epoxide equivalent in the range 150 to 2500, and more especially in the range 400 to 1000. Particular examples of such polyepoxides are those derived from epichlorhydrin and bis(4-hydroxyphenyl)-2,2-propane. These polyepoxides can be regarded as having the idealised structural formula (10):-



(10)

where  $\underline{p}$  is an integer such that the polyepoxide has an epoxide equivalent within the above range.

[0082] Polyepoxides of this type are available under the Trade Mark 'Epikote', in particular Epikote 1001, 1004 and 1007.

[0083] In addition, the composition can also comprise optional additives, for example UV absorbers and water scavengers or flow aids commonly used in paint formulations to modify application or final film properties.

[0084] The compositions of the invention can be prepared by mixing a co-polymer of the invention with a liquid carrier and any other optional additive.

[0085] The compositions of this invention can be used to coat an object by applying a film to the surface of the object by standard techniques for example by dipping, brushing, roller coating or spraying, allowing the solvent to evaporate and the film to cure.

[0086] The invention is illustrated by the following Examples where Examples 1, 3 to 21 and 23, 25, 27 and 28 illustrate the invention and Examples 2, 22, 24, 26 and 29 are comparative.

EXAMPLES

[0087] The properties of each polymer are displayed in Table 3.

[0088] Examples 1 to 17 are examples of hydroxyl functional polymers.

EXAMPLE 1Preparation of Polymer Dispersion 1

[0089] An initiator 'spike' comprising a mixture of tertiary butylperbenzoate (15.0g), butyl acetate (7.5g) and C<sub>10</sub> aromatic hydrocarbon solvent commercially available from Exxon as 'Solvesso' 100 (7.5g), ('Solvesso' is a trade mark) was added over 10 minutes with stirring to butyl acetate (592.5g) and 'Solvesso' 100 (592.5g) in an inert atmosphere heated at reflux.

[0090] A second mixture of hydroxyethyl methacrylate (725.4g), methyl methacrylate (729.2g), butyl acrylate (345.4g), tertiary butylperbenzoate (90.0g) and pentaerythritol tetramercaptopropionate (36.0g) was added over three hours to the solvent mixture heated at reflux.

[0091] The temperature was held at reflux for a further three hours.

[0092] Cooling the reaction product yielded Polymer 1 as a dispersion having a theoretical non volatile content of 60.0% which was diluted with butyl acetate (449.0g) and filtered under pressure  $10.3 \times 10^4$  Pa (15psi) through a filter bed of 'Celite 560', diatomaceous Silica, commercially available from Manville Corporation (Celite is a trade mark).

[0093] The molecular weight of the polymer was determined using the Gel Permeation Chromatography technique as described in Gel Chromatography, Theory, Methodology & Application, T Kremmer: L Boross, Wiley Interscience 1979.

[0094] Three 30cm 'PL Gel' (a trade name of Polymer Laboratories) columns, 10<sup>6</sup> A, 10<sup>4</sup> A, and 500 A respectively, were arranged in series in order that the high molecular weight polymer particles would be eluted first and were calibrated with ten polystyrene standards in the molecular weight range 600 to  $2.95 \times 10^6$  (available from Polymer Laboratories, Church Stretton, Shropshire) eluting with tetrahydrofuran at 1 cm<sup>3</sup> min<sup>-1</sup>. After calibration an aliquot of polymer under test was placed on the first column in the series and eluted in the same way.

Preparation of Clearcoat Composition 1

[0095] A Clearcoat was prepared by mixing together the following components to give an activation ratio of 1:1 hydroxyl groups to isocyanate groups:

1. Polymer 1 Dispersion (52.5% solids).	47.50g
2. An isocyanate trimer of hexamethylene diisocyanate, 90% solution in butyl acetate and 'Solvesso' 100 (1:1), commercially available from Bayer as 'Desmodur' N3390 or from Rhone Poulenc as 'Tolonate' HDT90.	16.74g
3. Butyl acetate.	34.61g
4. A slip aid, 50% solution in xylene, commercially available from Bayer as 'Baysilone' OL17.	0.15g
5. An anticrater agent, 50% solution in C <sub>9-10</sub> hydrocarbon, commercially available from BYK Chemie as 'BYK' 358.	0.60g
6. A 10% solution of dibutyltin dilaurate in butyl acetate.	0.40g

\* = Trade Mark

[0096] The resulting composition had a theoretical non volatile content of 40.0%.

EXAMPLES 2 TO 17EXAMPLE 2Preparation of Polymer Dispersion 2

[0097] A mixture of hydroxyethyl methacrylate (725.4g), butyl acrylate (345.4g), methyl methacrylate (729.2g) and tertiary butylperbenzoate (72.0g) was added over three hours with stirring to butyl acetate (600.0g) and 'Solvesso' 100 (600.0g) in an inert atmosphere heated at reflux.

\* = Trade Mark



[0098] The temperature was held at reflux for a further three hours.

#### Preparation of Clearcoat Composition 2

5 [0099] This was prepared exactly as described for Clearcoat Composition 1 using the quantities of each component as set out in Table 2.

#### EXAMPLE 3

##### 10 Preparation of Polymer Dispersion 3

[0100] A mixture of hydroxyethyl methacrylate (725.4g), butyl acrylate (345.4g), methyl methacrylate (729.2g), pentaerythritol tetramercaptopropionate (36.0g) and tertiary butylperbenzoate (90.0g) was added over three hours with stirring to butyl acetate (600.0g) and 'Solvesso' 100 (600.0g) in an inert atmosphere heated at reflux.

15 [0101] The temperature was held at reflux for a further three hours.

#### Preparation of Clearcoat Composition 3

20 [0102] This was prepared exactly as described for Clearcoat composition 1 using the quantities of each component as set out in Table 2.

#### EXAMPLE 4

##### Preparation of Polymer Dispersion 4

25 [0103] A mixture of hydroxyethyl methacrylate (725.4g), butyl acrylate (345.4g), methyl methacrylate (729.2g), pentaerythritol tetramercaptopropionate (72.0g) and 2,2-azobis(2-methyl-butynitrile) (126.0g, commercially available from Dupont as 'Vazo' 67) was added over three hours with stirring to butyl acetate (900.0g) and 'Solvesso' 100 (300.0g) in an inert atmosphere heated at reflux.

30 [0104] The temperature was held at reflux for a further three hours.

[0105] The product so obtained (theoretical non volatile content of 60.0%) was filtered as described in Example 1.

#### Preparation of Clearcoat Composition 4

35 [0106] This was prepared exactly as described for Clearcoat Composition 1 using the quantities of each component as set out in Table 2.

#### EXAMPLE 5

##### 40 Preparation of Polymer Dispersion 5

[0107] An initiator 'spike' comprising a mixture of tertiary butylperbenzoate (15.0g), butyl acetate (7.5g) and C<sub>10</sub> aromatic hydrocarbon solvent 'Solvesso' 100 (7.5g) was added over 10 minutes with stirring to butyl acetate (592.5g) and 'Solvesso' 100 (592.5g) in an inert atmosphere heated at reflux.

45 [0108] A second mixture of hydroxyethyl methacrylate (468.0g), methyl methacrylate (924.4g), butyl acrylate (407.6g), tertiary butylperbenzoate (90.0g) and pentaerythritol tetramercaptopropionate (36.0g) was added over three hours to the solvent mixture heated at reflux.

[0109] The temperature was held at reflux for a further three hours.

[0110] The product so obtained (theoretical non volatile content of 60.0%) was filtered as described in Example 1.

50

#### Preparation of Clearcoat Composition 5

[0111] This was prepared exactly as described for Clearcoat Composition 1 using the quantities of each component as set out in Table 2.

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\* = Trade Mark

**EXAMPLE 6**Preparation of Polymer Dispersion 6

5 [0112] An initiator 'spike' comprising a mixture of tertiary butylperbenzoate (15.0g), butyl acetate (7.5g) and C<sub>10</sub> aromatic hydrocarbon solvent 'Solvesso' 100 (7.5g) was added over 5 minutes with stirring to butyl acetate (592.5g) and 'Solvesso' 100 (592.5g) in an inert atmosphere heated at reflux.

[0113] A second mixture of hydroxyethyl methacrylate (468.0g), methyl methacrylate (1100.4g), butyl acrylate (231.6g), tertiary butylperbenzoate (90.0g) and pentaerythritol tetramercaptopropionate (36.0g) was added over three  
10 hours to the solvent mixture heated at reflux.

[0114] The temperature was held at reflux for a further three hours.

[0115] The product so obtained (theoretical non volatile content of 60.0%) was thinned with butyl acetate (463.1g) and filtered as described in Example 1.

15 Preparation of Clearcoat Composition 6

[0116] This was prepared exactly as described for Clearcoat Composition 1 using the quantities of each component as set out in Table 2.

20 **EXAMPLE 7**Preparation of Polymer Dispersion 7

25 [0117] A mixture of hydroxyethyl methacrylate (725.4g), butyl acrylate (723.6g), methyl methacrylate (351.0g), pentaerythritol tetramercaptopropionate (36.0g) and tertiary butylperbenzoate (126.0g) was added over three hours with stirring to butyl acetate (600.0g) and Solvesso\*100 (600.0g) in an inert atmosphere heated at reflux.

[0118] The temperature was held at reflux for a further three hours.

[0119] The product so obtained (theoretical non volatile content of 60.0%) was thinned with butyl acetate (3162.0g) and filtered as described in Example 1.

30 Preparation of Clearcoat Composition 7

[0120] This was prepared exactly as described for Clearcoat Composition 1 using the quantities of each component as set out in Table 2.

35 **EXAMPLE 8**Preparation of Polymer Dispersion 8

40 [0121] An initiator 'spike' comprising a mixture of tertiary butylperbenzoate (15.1g) and methyl propoxol acetate (15.1g) was added over 5 minutes with stirring to methyl propoxol acetate (1184.9g) in an inert atmosphere heated at reflux.

[0122] A second mixture of hydroxyethyl methacrylate (936.1g), methyl methacrylate (182.2g), butyl acrylate (681.7g), tertiary butylperbenzoate (90.2g) and pentaerythritol tetramercaptopropionate (36.1g) was added over three  
45 hours to the solvent mixture heated at reflux. The temperature was held at reflux for a further three hours.

[0123] The product so obtained was filtered under pressure 10.3 x 10<sup>4</sup> Pa (15psi) through a filter bed of 'Celite' 560.

Preparation of Clearcoat Composition 8a

50 [0124] This was prepared exactly as described for Clearcoat Composition 1 using the quantities of each component as set out in Table 2.

Preparation of Clearcoat Compositions 8b and 8c

55 [0125] Clearcoat Compositions 8a and 8b were prepared by mixing together the amounts of components as shown in Table 1 to give an activation ratio of hydroxyl groups to isocyanate groups of 1:1. (Figures are weight in grams).

\* = Trade Mark

Table 1

Formulations for Clearcoat Compositions 8b and 8c		
COMPONENTS	COMPOSITION	
	8b	8c
1. Polymer Dispersion 8.	47.54	52.54
2. Lumiflon <sup>*</sup> resin 926Z commercially available from Imperial Chemical Industries PLC, (5.0g).	5.00	0.00
3. UV absorber/light stabiliser, hindered amine/oxanilide, 30% solution in xylene commercially available from Sandoz AG as 'Sanduvor <sup>*</sup> 2312.	6.00	6.00
4. A 0.5% solution of dibutyltin dilaurate in xylene.	1.00	1.00
5. A slip aid, 50% solution in xylene commercially available from Bayer as 'Baysilon <sup>*</sup> OL17.	0.10	0.10
6. An anticrater agent, 50% solution in C <sub>9-10</sub> hydrocarbon, commercially available from BYK Chemie as 'BYK <sup>*</sup> 358.	0.70	0.70
7. Methyl ethyl ketone.	16.44	16.44
8. Butyl ethoxol acetate.	5.59	5.59
9. Butyl acetate.	2.04	2.04
10. Methyl propoxol acetate.	37.09	37.09
11. An isocyanate trimer of hexamethylene diisocyanate, 90% solution in butyl acetate and 'Solvesso <sup>*</sup> 100 (1:1), commercially available from Bayer as 'Desmodur <sup>*</sup> N3390.	32.39	32.39

\* = Trade Mark

**EXAMPLE 9****Preparation of Polymer Dispersion 9**

[0126] A mixture of hydroxyethyl methacrylate (725.4g), butyl acrylate (723.6g), methyl methacrylate (351.0g), dipentaerythritol hexamercaptopropionate (19.5g) and tertiary butylperbenzoate (36.0g) was added over three hours with stirring to butyl acetate (600.0g) and 'Solvesso<sup>\*</sup> 100 (600.0g) in an inert atmosphere heated at reflux.

[0127] The temperature was held at reflux for a further three hours.

[0128] The product so obtained was diluted with butyl acetate (2350.0g) and filtered as described in Example 1.

**Preparation of Clearcoat Composition 9**

[0129] This was prepared exactly as described for Clearcoat Composition 1 using the quantities of each component as set out in Table 2.

**EXAMPLE 10****Preparation of Polymer Dispersion 10**

[0130] An initiator 'spike' comprising a mixture of tertiary butylperbenzoate (15.23g) and methyl propoxol acetate (15.23g) was added over 5 minutes with stirring to methyl propoxol acetate (1185.05g) in an inert atmosphere heated at reflux.

[0131] A second mixture of hydroxyethyl methacrylate (836.0g), glycidyl methacrylate (90.1g), methyl methacrylate (195.4g), butyl acrylate (678.3g), tertiary butylperbenzoate (90.1g) and pentaerythritol tetramercaptopropionate (35.85g) was added over three hours to the solvent mixture heated at reflux. The temperature was held at reflux for a further one hour.

[0132] Para aminobenzoic acid (27.0g), followed by tertiary N,N dimethyl-N-alkylamine (4.4g) were added to the refluxing mixture. The temperature was held at reflux for a further 90 minutes.

[0133] The product so obtained was filtered as described in Example 1.

\* = Trade Mark

**EXAMPLE 11****Preparation of Polymer Dispersion 11**

5 [0134] A mixture of hydroxyethyl methacrylate (40.3g), butyl acrylate (40.2g), methyl methacrylate (19.5g), tertiary butylperbenzoate (2.0g) and pentaerythritol tetramercaptopropionate (1.0g) was added over three hours with stirring to butyl acetate (33.3g) and 'Solvesso' 100 (33.3g) in an inert atmosphere heated at reflux.

[0135] The temperature was held at reflux for a further three hours.

10 [0136] The product so obtained (theoretical non volatile content of 60.0%) was diluted with butyl acetate (51.4g) and filtered as described in Example 1.

**Preparation of Clearcoat Composition 11**

15 [0137] This was prepared exactly as described for Clearcoat Composition 1 using the quantities of each component as set out in Table 2.

**EXAMPLE 12****Preparation of Polymer Dispersion 12**

20 [0138] A mixture of hydroxyethyl methacrylate (40.3g), butyl acrylate (40.2g), methyl methacrylate (19.5g), tertiary butylperbenzoate (6.0g) and pentaerythritol tetramercaptopropionate (1.0g) was added over three hours with stirring to butyl acetate (33.3g) and 'Solvesso' 100 (33.3g) in an inert atmosphere heated at reflux.

25 [0139] The temperature was held at reflux for a further three hours.

**Preparation of Clearcoat Composition 12**

30 [0140] This was prepared exactly as described for Clearcoat Composition 1 using the quantities of each component as set out in Table 2.

**EXAMPLE 13****Preparation of Polymer Dispersion 13**

35 [0141] A mixture of hydroxyethyl methacrylate (40.3g), butyl acrylate (40.2g), methyl methacrylate (19.5g), tertiary butylperbenzoate (6.0g) and pentaerythritol tetramercaptopropionate (3.0g) was added over three hours with stirring to butyl acetate (33.3g) and 'Solvesso' 100 (33.3g) in an inert atmosphere heated at reflux.

[0142] The temperature was held at reflux for a further three hours.

40 **Preparation of Clearcoat Composition 13**

[0143] This was prepared exactly as described for Clearcoat Composition 1 using the quantities of each component as set out in Table 2.

45 **EXAMPLE 14**

**Preparation of Polymer Dispersion 14**

50 [0144] An initiator 'spike' comprising a mixture of tertiary butylperbenzoate (15.0g), butyl acetate (7.5g) and C<sub>10</sub> aromatic hydrocarbon solvent 'Solvesso' 100 (7.5g) was added over 10 minutes with stirring to butyl acetate (592.5g) and 'Solvesso' 100 (592.5g) in an inert atmosphere heated at reflux.

[0145] A second mixture of hydroxyethyl methacrylate (234.0g), methyl methacrylate (1110.2g), butyl acrylate (455.8g), tertiary butylperbenzoate (90.0g) and pentaerythritol tetramercaptopropionate (36.0g) was added over three hours to the solvent mixture heated at reflux.

55 [0146] The temperature was held at reflux for a further three hours.

[0147] The product so obtained was filtered as described in Example 1.

\* = Trade Mark

Preparation of Clearcoat Composition 14

**[0148]** This was prepared exactly as described for Clearcoat Composition 1 using the quantities of each component as set out in Table 2.

EXAMPLE 15Preparation of Polymer Dispersion 15

**[0149]** An initiator 'spike' comprising a mixture of tertiary butylperbenzoate (15.0g), butyl acetate (7.5g) and C<sub>10</sub> aromatic hydrocarbon solvent 'Solvesso' 100 (7.5g) was added over 10 minutes with stirring to butyl acetate (592.5g) and 'Solvesso' 100 (592.5g) in an inert atmosphere heated at reflux.

**[0150]** A second mixture of hydroxyethyl methacrylate (351.0g), methyl methacrylate (1017.0g), butyl acrylate (432.0g), tertiary butylperbenzoate (90.0g) and pentaerythritol tetramercaptopropionate (36.0g) was added over three hours to the solvent mixture heated at reflux.

**[0151]** The temperature was held at reflux for a further three hours.

**[0152]** The product so obtained was thinned with butyl acetate (666.0g) and filtered as described in Example 1.

Preparation of Clearcoat Composition 15

**[0153]** This was prepared exactly as described for Clearcoat Composition 1 using the quantities of each component as set out in Table 2.

EXAMPLE 16Preparation of Polymer Dispersion 16

**[0154]** An initiator 'spike' comprising a mixture of tertiary butylperbenzoate (15.0g), butyl acetate (7.5g) and C<sub>10</sub> aromatic hydrocarbon solvent 'Solvesso' 100 (7.5g) was added over 10 minutes with stirring to butyl acetate (592.5g) and 'Solvesso' 100 (592.5g) in an inert atmosphere heated at reflux.

**[0155]** A second mixture of hydroxyethyl methacrylate (585.0g), methyl methacrylate (831.0g), butyl acrylate (384.0g), tertiary butylperbenzoate (90.0g) and pentaerythritol tetramercaptopropionate (36.0g) was added over three hours to the solvent mixture heated at reflux.

**[0156]** The temperature was held at reflux for a further three hours.

**[0157]** The product so obtained was thinned with butyl acetate (401.0g) filtered as described in Example 1.

Preparation of Clearcoat Composition 16

**[0158]** This was prepared exactly as described for Clearcoat Composition 1 using the quantities of each component as set out in Table 2.

EXAMPLE 17Preparation of Polymer Dispersion 17

**[0159]** A mixture of hydroxyethyl methacrylate (40.3g), butyl acrylate (40.2g), methyl methacrylate (19.5g), tertiary butylperbenzoate (6.0g) and pentaerythritol tetramercaptopropionate (1.0g) was added over three hours with stirring to butyl acetate (33.3g) and 'Solvesso' 100 (33.3g) in an inert atmosphere heated at reflux.

**[0160]** The temperature was held at reflux for a further three hours.

**[0161]** The product so obtained (theoretical non volatile content of 60.0%) was diluted with butyl acetate (177.0g) and filtered as described in Example 1.

Preparation of Clearcoat Composition 17

**[0162]** This was prepared exactly as described for Clearcoat Composition 1 using the quantities of each component as set out in Table 2.

\* = Trade Mark

EXAMPLE 18Preparation of Polymer 18

- 5 [0163] An Example of a carboxy functional polymer.  
 [0164] A mixture of ethyl acrylate (506.8g), methyl methacrylate (506.8g), acrylic acid (438.7g), tertiary butyl-per-2-ethyl hexanoate (36.3g) and pentaerythritol tetramercaptopropionate (36.3g) was added over three hours with stirring to propylene glycol methyl ether (969.0g) heated at reflux.  
 [0165] After 15 minutes tertiary butyl-per-2-ethyl hexanoate (1.69g) was added to the mixture. A similar addition was  
 10 made after 10 minutes. A further four additions at intervals of 10 minutes were made to the mixture heated at reflux.  
 [0166] The temperature was held at reflux for a further 15 minutes.

EXAMPLE 19Preparation of Polymer Dispersion 19

- [0167] An Example of an epoxy functional polymer.  
 [0168] A mixture of glycidyl methacrylate (396.18g), methyl methacrylate (1008.18g), butyl acrylate (395.64g), tertiary butyl perbenzoate (90.0g) and pentaerythritol tetramercaptopropionate (36.0g) was added over three hours with stirring  
 20 to butyl acetate (600.0g) and C<sub>10</sub> aromatic hydrocarbon solvent 'Solvesso' 100 (600.0g) heated at reflux.  
 [0169] The temperature was held at reflux for three hours.

EXAMPLE 20Preparation of Polymer Dispersion 20

- [0170] An Example of an allyl functional polymer.  
 [0171] A mixture of ethyl acrylate (506.8g), methyl methacrylate (506.8g), acrylic acid (438.7g), tertiary butyl per-2-ethylhexanoate (25.34g) and pentaerythritol tetra mercaptopropionate (25.34g) was added over three hours with  
 30 stirring to 1-methoxy-2-hydroxy propane (969.0g) heated at reflux.  
 [0172] After 15 minutes, tertiary butyl per-2-ethylhexanoate (1.69g) was added to the mixture. A similar addition was made after 10 minutes. A further four additions at intervals of 10 minutes were made to the mixture heated at reflux.  
 [0173] The temperature was held at reflux for a further 15 minutes then reduced to 70°C.  
 [0174] A mixture of allyl glycidyl ether (578.7g) and benzyl trimethyl ammonium hydroxide (8.68g) was added to the  
 35 cooled solution. The temperature of the mixture was then raised to reflux and maintained for five hours.

EXAMPLE 21Preparation of Polymer Dispersion 21

- 40 [0175] An example of an allyl functional polymer.  
 [0176] A mixture of ethyl acrylate (16.37 parts), methyl methacrylate (16.37 parts), acrylic acid (14.17 parts), tertiary butyl per-2-ethylhexanoate (1.17 parts) and pentaerythritol tetra mercaptopropionate (1.17 parts) was added over three hours with stirring to 1-methoxy-2-hydroxy propane (31.30 parts) heated at reflux. After 5 minutes, tertiary butyl per-2-ethylhexanoate (0.08 parts) was added to the mixture. A similar addition was made after 10 minutes. A further four  
 45 additions at intervals of 10 minutes were made to the mixture heated at reflux.  
 [0177] The temperature was held at reflux for a further 15 minutes then reduced to 70°C.  
 [0178] Allyl glycidyl ether (18.69 parts) followed by benzyl trimethyl ammonium hydroxide (an oxirane-ring opening catalyst, 0.29 parts) was added to the cooled solution. The temperature of the mixture was then raised to reflux and  
 50 maintained for five hours, or until the Epoxy value < 5mg KOH/g Non Volatile material.  
 [0179] The final product had a viscosity of 33 seconds as measured using a bubble tube at a temperature of 25°C and a non volatile content of 65.0%.

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\* = Trade Mark

**EXAMPLE 22****Preparation of Polymer Dispersion 22**

- 5 **[0180]** An example of a linear allyl functional polymer.
- [0181]** A mixture of ethyl acrylate (16.39 parts), methyl methacrylate (16.39 parts), acrylic acid (14.19 parts) and tertiary butyl per-2-ethylhexanoate (2.35 parts) was added over three hours and thirty minutes with stirring to 1-methoxy-2-hydroxy propane (28.38 parts) heated at reflux.
- 10 **[0182]** After 15 minutes a mixture of tertiary butyl per-2-ethylhexanoate (0.47 parts) and 1-methoxy-2-hydroxy propane (3.01 parts) was added over 15 minutes to the above mixture heated at reflux.
- [0183]** The temperature was maintained at reflux for a further 1 hour then reduced to 112°C.
- [0184]** Allyl glycidyl ether (18.53 parts), followed by benzyl trimethyl ammonium hydroxide (0.28 parts) and 1-methoxy-2-hydroxy propane (0.44 parts) were added to the cooled solution. The temperature of the mixture was then raised to reflux and maintained for five hours, or until the Epoxy value < 5mg KOH/g Non Volatile material.
- 15 **[0185]** The final product had a viscosity of 28 seconds as measured using a bubble tube at a temperature of 25°C and a non volatile content of 65.6%.

**EXAMPLE 23****Preparation of Polymer Dispersion 23**

- [0186]** A mixture of hydroxy ethyl acrylate (445.4g) and ethyl acrylate (190.9g) was fed over a period of three hours concurrently with a mixture of tertiary butyl per-2-ethylhexanoate (10.09g), pentaerythritol tetra mercaptopropionate (12.72g) and 1-methoxy-2-hydroxy propane (1.1g) with stirring to a mixture of 1-methoxy-2-hydroxy propane (197.2g) and demineralised water (131.9g) heated at reflux.
- 25 **[0187]** After 15 minutes, tertiary butyl perbenzoate (6.4g) was added over a period of 50 minutes to the mixture heated at reflux.
- [0188]** The temperature was maintained for a further 20 minutes.
- [0189]** The resulting product had a viscosity of 9.0 seconds as measured using a bubble tube at a temperature of 25°C and a non volatile content of 60.0%.
- 30

**Preparation of Clearcoat Composition 23**

- [0190]** A clearcoat was prepared by blending together the following components. The composition was then acidified to a pH of 1.0 using toluene sulphonic acid solution (25% in water).
- 35

1. Polymer Dispersion 23	30.00g
2. Tetramethylol glycoluril solution (45% in water) (Commercially available from Dyno-Cyanamid as 'Cymel'® 1172)	12.51g
3. Water	12.54g

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\* = Trade Mark

**EXAMPLE 24****Preparation of Polymer Dispersion 24**

- [0191]** A mixture of hydroxy ethyl acrylate (445.4g) and ethyl acrylate (190.9g) was fed over a period of three hours concurrently with tertiary butyl per-2-ethylhexanoate (31.8g) with stirring to a mixture of 1-methoxy-2-hydroxy propane (197.2g) and demineralised water (131.9g) heated at reflux.
- 50 **[0192]** After 15 minutes, tertiary butyl perbenzoate (6.36g) was added over a period of 50 minutes to the mixture heated at reflux.
- [0193]** The temperature was maintained for a further 15 minutes.
- [0194]** The final product had a viscosity of 8.0 seconds as measured using a bubble tube at a temperature of 25°C and a non volatile content of 60.0%.
- 55

Preparation of Clearcoat Composition 24

[0195] A clearcoat was prepared by blending together the following components. The composition was then acidified to a pH of 1.0 using toluene sulphonic acid solution (25% in water).

1. Polymer Dispersion 24	30.04g
2. Tetramethylol glycoluril solution (45% in water) (Commercially available from Dyno-Cyanamid as 'Cymel** 1172)	12.16g
3. Water	13.96g

\* = Trade Mark

[0196] Table 2 shows the quantities of each component, required to prepare Clearcoat compositions 1 to 7, 8a, 9 and 11 to 17.

Table 2

Formulations for Clearcoat Compositions 1 to 7, 8a, 9 and 11 to 17							
CLEARCOAT COMPOSITION	POL. No.	DISP'N (g)	STARTING MATERIALS:				
			2.	3.	4.	5.	6.
1	1	47.50	16.74	34.61	0.15	0.60	0.40
2	2	39.81	16.74	42.30	0.15	0.60	0.40
3	3	38.36	16.74	43.75	0.15	0.60	0.40
4	4	41.63	16.74	40.48	0.15	0.60	0.40
5	5	55.04	12.47	31.34	0.15	0.60	0.40
6	6	55.04	12.47	31.34	0.15	0.60	0.40
7	7	42.99	16.74	39.12	0.15	0.60	0.40
8a	8	35.79	19.47	43.59	0.15	0.60	0.40
9	9	41.95	16.74	40.16	0.15	0.60	0.40
11	11	52.98	16.60	8.64	0.15	0.60	0.40
12	12	40.24	16.60	41.97	0.15	0.60	0.40
13	13	40.30	16.60	41.91	0.15	0.60	0.40
14	14	56.30	7.2	35.50	0.60	---	0.40
15	15	62.10	10.0	26.90	0.60	---	0.40
16	16	50.2	14.4	43.30	0.60	---	0.40
17	17	76.47	16.6	6.38	0.15	---	0.40

where the starting materials are:-

2. An isocyanate trimer of hexamethylene diisocyanate, 90% solution in butyl acetate and 'Solvesso' 100 (1:1), commercially available from Bayer as 'Desmodur\*\* N3390 or from Rhone Poulenc as 'Tolonate\*\* HDT90.

3. Butyl acetate.

4. A slip aid, 50% solution in xylene, commercially available from Bayer as 'Baysilone\*\* OL17.

5. An anticrater agent, 50% solution in C<sub>9-10</sub> hydrocarbon, commercially available from BYK Chemie as 'BYK\*\*358.

6. A 10% solution of dibutyltin dilaurate in butyl acetate.

[0197] The properties of Polymer Dispersions 1 to 24 are shown in Table 3 below:

\* = Trade Mark



Table 3

Properties of Polymer Dispersions 1 to 24					
POLYMER DISP'N	FUNCTIONAL GROUP	FUNCTIONALITY (%)	NON VOL (%)	Tg (°C)	MOLECULAR WEIGHT (Mw)
1	Hydroxyl	35.80	52.50	41	7,092
2	"	35.80	62.64	41	6,774
3	"	35.80	65.00	41	14,061
4	"	35.80	59.00	41	3,770
5	"	22.46	61.50	40	9,006
6	"	21.93	52.30	60	8,641
7	"	37.86	58.00	5	8,366
8	"	50.18	62.80	5	7,446
9	"	37.86	34.35	5	13,807
10	" WG	42.94 1.36	61.10	5	9,921
11	"	37.85	46.60	5	15,285
12	"	37.85	61.40	5	8,013
13	"	37.85	61.40	5	9,705
14	"	10.93	59.10	40	9,089
15	"	16.62	49.50	40	6,382
16	"	28.46	53.20	40	9,515
17	"	37.85	52.80	5	7,453
18	Carboxyl	31.23	60.00	48	27,769
19	Epoxy	17.48	60.00	41	7,349
20	Allyl Carboxyl	23.83 4.77	67.70		17,387
21	Allyl Carboxyl	23.82 4.78	65.00		27,377
22	Allyl Carboxyl	23.64 5.03	65.60		14,164
23	Hydroxy	66.79	66.20		11,923
24	Hydroxy	66.79	65.60		7,232

where

WG means wetting groups.

[0198] FUNCTIONALITY is expressed as the mole percentage of functional group-containing monomers as a percentage of total monomers (excluding thiol hub portion) making up the total polymer.

[0199] MOLECULAR WEIGHT is expressed as the apparent weight average molecular weight of the polymer.

#### EXAMPLE 25

##### Preparation of Primer Composition 25

##### (a) Preparation of Pigment Millbase

[0200] Polymer 6 (1146.9g) was charged to a premix vessel containing butyl acetate (540.9g) and xylene (545.6g). A mixture of Bentone 34 (25.0g; commercially available from Steetley-Berk Ltd.), synthetic barium sulphate (681.0g), aluminium/magnesium silicates (428.5g), yellow iron oxide (77.5g), zinc/aluminium phosphate (428.5g), titanium dioxide (474.5g) and magnesium silicate (599.0g) was added to the premix vessel. The mixture was stirred and passed through an EIGERbead mill running at 3000rpm until a fineness of 25 micrometers was achieved.

##### (b) Preparation of Hardener

[0201] To a mixture of methyl propoxol acetate (20.0g), butyl acetate (10.0g) and 'Solvesso' 100 (20.0g), an isocyanate trimer of hexamethylene diisocyanate, 90% solution in butyl acetate and 'Solvesso' 100 (1:1), (48.0g; commercially available from Rhone Poulenc as 'Tolonate' HDT90 ) and triethyl ortho formate (2.0g) were added and the mixture stirred together.

\* = Trade Mark

(c) Preparation of Primer Composition

[0202] The following components were mixed together to give an activation ratio of 1:1 hydroxyl groups to isocyanate groups:

1.	Pigment Millbase as described in (a)	98.30g
2.	Hardener as described in (b)	25.00g
3.	Triethyl ortho formate	0.86g
4.	Dibutyltin dilaurate	0.07g
5.	Calcium salt toluene sulphonic acid	0.43g
6.	3-methacryloxypropyltrimethoxy-silane	0.34g
7.	Butyl acetate	20.00g
8.	Methyl propoxol acetate	3.75g
9.	'Solvesso'* 100	1.25g

\* = Trade Mark

[0203] This gave a product with a viscosity of 18.3 seconds in a British Standard B4 viscosity cup at 23°C and a pot life of 120 minutes. Where the pot life is measured to be the time for the viscosity to double.

EXAMPLE 26Primer Composition 26

[0204] Example 26 is a comparative Example based upon a commercially available 2 component primer coating based on linear polymers. The composition is called '2K Extrafiller\*P565-761' and is available from Imperial Chemical Industries PLC. It has a viscosity of 19.7 seconds in a British standard B4 viscosity cup at 23°C and a pot life of 60 minutes. Pot life means the time for the viscosity to double.

EXAMPLE 27Preparation of Coating Composition 27(a) Preparation of Pigment Millbase

[0205] Polymer 10 (115.68g) was charged to a premix vessel containing methyl propoxol acetate (58.48g). A mixture of hostaperm violet RL (4.8g), heliogen blue L7101F (3.84g), carbon black (3.2g), titanium dioxide (14.64g) and monas-tral green GNC (0.96g) was added to the premix vessel and mixed at 3500rpm for 20 minutes.

[0206] The mixture was passed through a NETZSCH bead mill until a fineness of 5 micrometers (microns) was achieved.

(b) Preparation of Coating Composition

[0207] The following components were mixed together to give an activation ratio of 1:1 hydroxyl groups isocyanate groups:

1.	Polymer 8	60.40g
2.	Lumiflon*resin 926X commercially available from Imperial Chemical Industries PLC.	5.0g
3.	Pigment millbase as described in (a).	25.2g
4.	Light stabiliser, hindered amine commercially available from Ciba Geigy SA as 'Tinuvin'*292.	0.2g
5.	UV absorber / Light stabiliser, benzotriazole derived product commercially available from Ciba Geigy SA as 'Tinuvin'*900.	1.0g
6.	A 0.5% solution of dibutyl tin dilaurate in xylene.	1.5g
7.	A slip aid, 50% solution in xylene commercially available from Bayer as 'Baysilone'*OL17.	0.1g
8.	An anticrater agent, 50% solution in C <sub>9-10</sub> hydrocarbon, commercially available from BYK Chemie as 'BYK'*358.	0.3g
9.	Methyl isobutyl ketone.	17.0g
10.	An isocyanurate trimer of hexamethylene diisocyanate, 90% solution in butyl acetate, commercially available from Bayer as 'Desmodur'*N3390.	26.2g

\* = Trade Mark

(continued)

11. A biuret of hexamethylene diisocyanate, 75% solution in methyl propoxol acetate and xylene (1:1), commercially available from Bayer as 'Desmodur'*N75.	13.1g
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\* = Trade Mark

[0208] This gave a product with a viscosity of 29 seconds in a British Standard B3 viscosity cup at 25°C and a pot life of 240 minutes. Pot life means the time for the viscosity to double.

EXAMPLE 28Preparation of Coating Composition 28

[0209] The following components were mixed together to give an activation ratio of 1:1 hydroxyl groups isocyanate groups:

1. Polymer B.	65.4g
2. Pigment millbase as described in (a).	25.2g
3. Light stabiliser, hindered amine commercially available from Ciba Geigy SA as 'Tinuvin'*292.	0.2g
4. UV absorber/Light stabiliser, benzotriazole derived product commercially available from Ciba Geigy SA as 'Tinuvin'*900.	1.0g
5. A 0.5% solution of dibutyltin dilaurate in xylene.	1.5g
6. A slip aid, 50% solution in xylene commercially available from Bayer as 'Baysilone'*OL17.	0.1g
7. An anticrater agent, 50% solution in C <sub>9-10</sub> hydrocarbon, commercially available from BYK Chemie as 'BYK'*358.	0.3g
8. Methyl isobutyl ketone.	17.0g
9. An isocyanurate trimer of hexamethylene diisocyanate, 90% solution in butyl acetate, commercially available from Bayer as 'Desmodur'*N3390.	26.2g
10. An biuret of hexamethylene diisocyanate, 75% solution in methyl propoxol acetate and xylene (1:1), commercially available from Bayer as 'Desmodur'*N75.	13.1g

\* = Trade Mark

EXAMPLE 29Preparation of Coating Composition 29

[0210] This is a commercially available two component polyurethane gloss finish based on a linear polymer available from Imperial Chemical Industries PLC as F407-701 and F210-731.

[0211] The composition is prepared by mixing together F407-701 (2 parts by volume) with F210-731 (1 part by volume) and methyl isobutyl ketone (1 part by volume) to give a product having a viscosity of 29 seconds in a British Standard B3 viscosity cup at 25°C and a pot life of 360 minutes. Pot life means the time for the viscosity to double.

POT LIFE AND GEL TIME MEASUREMENTSPot Life

[0212] The pot life of Clearcoat Compositions 1 to 7, 8a and 9 was measured in minutes and means the time for the viscosity of the clearcoat (as measured using a BSB4 viscosity cup) when first prepared (activated with isocyanate) to double.

Gel Time

[0213] The gel time of Clearcoat Compositions 1 to 7, 8a and 9 was measured in minutes and means the time for the clearcoat to become immobile.

[0214] Table 4 below shows the initial viscosity (when first activated) as measured in a British Standard B4 viscosity cup at 22°C of each clearcoat composition, the time in minutes for it to double (Pot Life) and the time in minutes for

the clearcoat to become immobile (Gel Time).

Table 4

Pot Life and Gel Time of Clearcoat Compositions 1 to 9				
CLEARCOAT COMPOSITION	POLYMER TYPE	VISCOSITY BSB4 (22°C) (SECS)	POT LIFE (MINS)	GEL TIME (MINS)
1	4 arm Star / Med M. Wt./ Med OH Func./ Med Tg	17.3	225	270
2	Linear / Med M. Wt./ Med OH Func./ Med Tg	21.3	60	90
3	4 arm Star / High M. Wt./ Med OH Func./ Med Tg	24.8	40	60
4	4 arm Star / Low M. Wt./ Med OH Func./ Med Tg	16.5	90	120
5	4 arm Star / Med M. Wt./ Low OH Func./ Med Tg	22.2	180	355
6	4 arm Star / Med M. Wt./ Low OH Func./ High Tg	21.0	210	385
7	4 arm Star / Med M. Wt./ Med OH Func. / Low Tg	16.6	210	255
8a	4 arm Star / Med M. Wt./ High OH Func. / Low Tg	16.2	90	125
9	6 arm Star / High M. Wt./ Med OH Func. / Low Tg	19.6	130	180

[0215] It can be seen from Table 4 that Clearcoat Composition 1 containing a star polymer exhibits a lower viscosity and longer pot life than the equivalent composition containing a linear polymer (Clearcoat Composition 2).

#### WATER RESISTANCE TEST

[0216] Clearcoat Compositions 23 and 24 were tested for their resistance to water using the following method:

[0217] A coating 50 to 60 micrometers thick was applied at 20°C and 50% relative humidity to a dry coat of conventional liquid gloss alkyd paint (such as "Dulux" brilliant white liquid gloss) after the coat had been allowed to dry at 20°C and 50% relative humidity for at least 7 days. The coating was allowed to dry for 24 hours at 20°C and 50% relative humidity. Then a 1 ml drop of water was deposited onto it and covered with a watch glass and allowed to stand at 20°C for two hours. The glass was removed and the sample immediately wiped dry and examined for disfiguration at 24 hours and one week after spreading.

[0218] Table 5 below shows the water resistance of Clearcoat Compositions 23 and 24.

Table 5

Water Resistance of Clearcoat Compositions 23 and 24		
CLEARCOAT COMPOSITION	WATER RESISTANCE	
	24 HOURS	1 WEEK
23	Clear	Clear

\* = Trade Mark

Table 5 (continued)

Water Resistance of Clearcoat Compositions 23 and 24		
CLEARCOAT COMPOSITION	WATER RESISTANCE	
	24 HOURS	1 WEEK
24	Blisters Present	Clear

[0219] It can be seen from Table 5 that Clearcoat Composition 23 which is based upon a Star polymer gives better early resistance to water than the equivalent Clearcoat composition based upon a linear polymer (24).

#### APPLICATION AND TESTING OF THE COATING COMPOSITIONS

##### Application

[0220] Primer Compositions 25 and 26 are suitable for use as an undercoat for re-spraying motor vehicles. The compositions were sprayed over bare steel substrates to a dry film thickness of 75-100 micrometers. Coating Compositions 27 and 29 are suitable for use as coatings for aircraft. The compositions were sprayed over aluminium 20 SWG substrate coated with a standard chromate-containing epoxy primer, (commercially available from Imperial Chemical Industries PLC as F580-2080) to a dry film thickness of 15 micrometers.

##### Tests for Primer Compositions 25 and 26

##### [0221]

Wet Sanding : The coated substrate is sanded with P800 grade wet or dry paper (commercially available from 3M) in the presence of water at 60 minutes after application of the coating. A further sample of the coated substrate is sanded as above at 120 minutes after application. The condition of the wet or dry paper is noted.

Dry Sanding: The coated substrate is sanded with an air driven double action random orbital sander with P360 grade dry sanding paper commercially available from 3M, at 60 minutes after application of the coating. A further sample of the coated substrate is sanded as above at 120 minutes after application. The condition of the dry sanding paper is noted.

##### Tests for Coating Compositions 27 and 29

##### [0222]

'Skydrol'® Immersion and Scratch Test: The coated substrate is placed in hot (70°C) phosphate ester based hydraulic fluid commercially available from Monsanto as 'Skydrol'®500 for a period of 14 days. The substrate is then removed from the fluid, wiped dry and a scratch test according to BS 3900 : Part E2 is performed immediately.

Water Immersion and Scratch Test: The coated substrate is placed in a demineralised water bath at a temperature of 23°C for 14 days. The substrate is then removed from the bath, wiped dry and a scratch test according to BS 3900 : Part E2 is performed immediately.

Ultra Violet Light Resistance : The coated substrate is tested for its resistance to ultra violet light according to ASTM G53. Gloss readings using a 20° gloss meter are taken over a period of three weeks of exposure.

##### Results

##### [0223]

Table 6

Sanding Results for Primer Compositions 25 and 26				
Primer Composition	Wet Sanding		Dry Sanding	
	60 mins	120 mins	60 mins	120 mins
25	Good	Good	Good	Good

\* = Trade Mark

Table 6 (continued)

Sanding Results for Primer Compositions 25 and 26				
Primer Composition	Wet Sanding		Dry Sanding	
	60 mins	120 mins	60 mins	120 mins
26	Poor	Good	Poor	Good

[0224] Where:

- Good - Surface powders well with acceptable level of clogging of the sanding paper.  
 Poor - Unacceptable level of clogging of the sanding paper, i.e. the sanding paper either polishes the surface of the coating or tears the film.

[0225] It can be seen from Table 7 that Primer Composition 25 which is based on a star polymer has a longer pot life and earlier cure as seen by its early sanding ability.

[0226] Tables 7 and 8 show the results for Coating Compositions 27 and 29.

Table 7

Results of Scratch Tests for Coating Compositions 27 and 29		
Coating Composition	'Skydrol' & Scratch	Water & Scratch
27	Pass 1500g, Fail 2000g	Pass 2000g
29	Pass 1500g, Pass 2000g	Pass 2000g

\* = Trade Mark

Table 8

Results of UV Resistance for Coating Compositions 27 and 29							
Coating Composition	U V Resistance (gloss reading)						
	0h	91h	168h	220h	384h	465h	552h
27	80.9	-	82.9	-	81.5	-	80.4
29	80.5	72.3	-	74.8	-	60.0	-

where 'h' is hours of exposure.

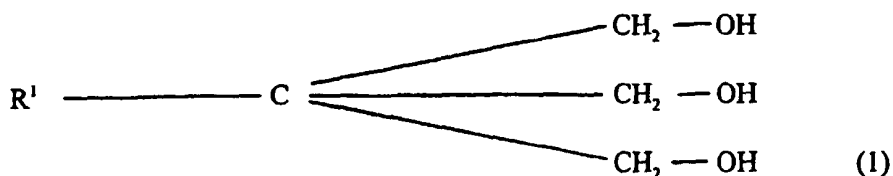
[0227] It can be seen from Tables 7 and 8 that Coating Composition 27 which is based on a star polymer has an excellent resistance to U V exposure and an acceptable resistance to 'Skydrol'.

#### Claims

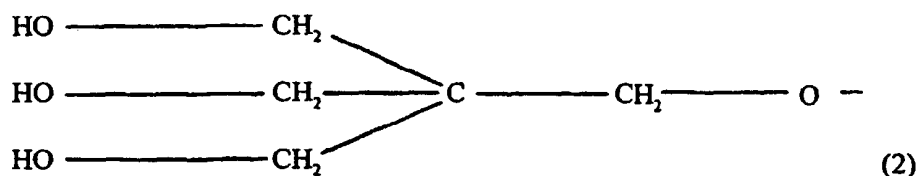
1. A crosslinkable coating composition comprising a star co-polymer and a liquid diluent or carrier characterised in that the star co-polymer has a hub portion from which radiate from 3 to 8 arms where the hub portion is the residue of a tri-functional to octa-functional thiol ester, formed from a tri-functional to octa-functional alcohol and thio C<sub>2-6</sub> alkanolic acid, and each arm is an addition polymer comprising structural units and functional units where the functional units, but not the structural units, include crosslinking substituents and are mutually compatible in that the crosslinking substituents are capable of undergoing a crosslinking reaction, with either a crosslinking agent, in which case the composition also comprises a crosslinking agent, or the same or a complementary substituent in functional units in another molecule of the same polymer, and optionally compatible auxiliary functional units that contain wetting groups.
2. A coating composition as claimed in claim 1 where the co-polymer has a total weight average molecular weight of from 3 000 to 30 000 inclusive.

\* = Trade Mark

3. A coating composition as claimed in Claim 1 or claim 2 where the co-polymer has 3, 4 or 6 arms.
4. A coating composition as claimed in claim 3 where the co-polymer has 4 or 6 arms.
5. A coating composition as claimed in any one of claims 1 to 4 where the alcohol from which the thio ester is formed has the formula (1);



where R<sup>1</sup> is hydrogen, C<sub>1-4</sub> alkyl, hydroxy C<sub>1-4</sub> alkyl or a group of formula (2);

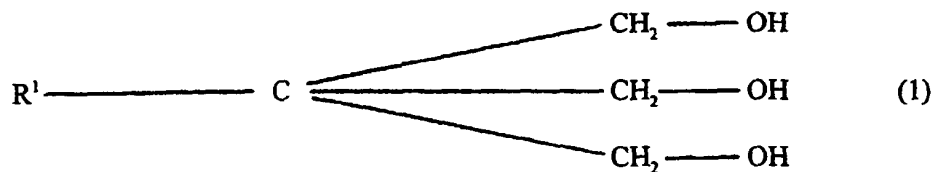


6. A coating composition as claimed in any one of claims 1 to 5 where the thio C<sub>2-6</sub> alkanolic acid is 2-mercaptoacetic or 3-mercaptopropionic acid.
7. A coating composition as claimed in any one of claims 1 to 6 where the functional units all contain the same crosslinking substituent and the substituent is, an hydroxyl group, an isocyanate group, an epoxy group, a carboxy group or a salt thereof or an allyl or 2-hydroxy-3-allyl oxypropyl ester derivative thereof.
8. A coating composition as claimed in any one of claims 1 to 6 having two different types of functional groups and one type of functional group contains hydroxyl groups and the other contains carboxyl groups or hydroxyl and blocked isocyanate groups, hydroxyl and epoxy groups or carboxyl groups or salts thereof and allyl or 2-hydroxy-3-allyl oxypropyl ester groups.
9. A coating composition as claimed in any one of claims 1 to 8 and comprising an auxilliary functional unit containing a wetting group.
10. A coating composition as claimed in claim 9 where the substituent in the functional group is other than isocyanate and the wetting group is 4-nitro or 4-amino benzoyl ester.
11. A coating composition as claimed in any one of claims 1 to 10 where the total average mole percentage of functional and auxilliary functional units in each arm is 0.5 to 5 mole %.
12. A coating composition as claimed in any one of claims 1 to 7 where the functional units are derived from allyl alcohol or glycidyl methacrylate or acrylate and methacrylate esters of formula (3);

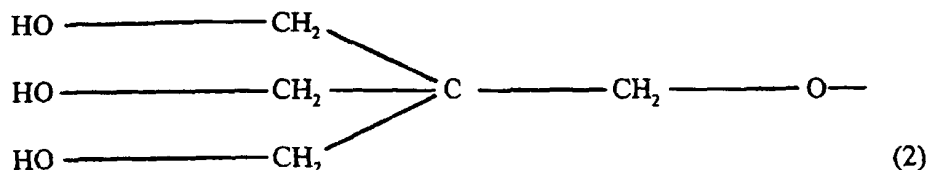


where R<sup>1</sup> is hydrogen or methyl and R<sup>2</sup> is C<sub>2-6</sub> alkane diyl.

13. A coating composition as claimed in claim 12 where  $R^2$  is butane-1,4-diyl and  $R^1$  is hydrogen or  $R^1$  is methyl and  $R^2$  is ethane-1,2-diyl.
14. A coating composition as claimed in any one of claims 1 to 13 where the structural units are units derived from  $C_{1-8}$  alkyl esters of acrylic or methacrylic acids, vinyl  $C_{2-6}$  alkanates and styrene and its  $C_{1-4}$  alkyl analogues.
15. A coating composition as claimed in claim 14 where the structural units are derived from methyl methacrylate, ethyl methacrylate, butyl methacrylate and butyl acrylate.
16. A process for coating an object which comprises applying to the surface of the object a film of coating composition as claimed in any one of claims 1 to 15 and allowing the polymer film to crosslink.
17. A star co-polymer having a weight average molecular weight of from 3 000 to 30 000 inclusive and having a hub portion from which radiate from 3 to 8 arms where the hub portion is the residue of a tri-functional to octa-functional thiol ester, formed from a tri-functional to octa-functional alcohol and thio  $C_{2-6}$  alkanic acid, and each arm is an addition polymer comprising structural units and functional units where the functional units, but not the structural units, include crosslinking substituents and are mutually compatible in that the crosslinking substituents are capable of undergoing a crosslinking reaction with a crosslinking agent or the same or a complementary substituent in functional units in another molecule of the same polymer, and optionally compatible auxiliary functional units that contain wetting groups.
18. A co-polymer as claimed in Claim 17 where the co-polymer has 3, 4 or 6 arms.
19. A co-polymer as claimed in claim 18 where the co-polymer has 4 or 6 arms.
20. A co-polymer as claimed in any one of claims 17 to 19 where the alcohol from which the thiol ester is formed has the formula (1);



where  $R^1$  is hydrogen,  $C_{1-4}$  alkyl, hydroxy  $C_{1-4}$  alkyl or a group of formula (2);



21. A co-polymer as claimed in any one of claims 17 to 20 where the thio  $C_{2-6}$  alkanic acid is 2-mercaptoacetic or 3-mercaptopropionic acid.
22. A co-polymer as claimed in any one of claims 17 to 21 where the functional units all contain the same crosslinking substituent and the substituent is, an hydroxyl group, an isocyanate group, an epoxy group, a carboxy group or a salt thereof or an allyl or 2-hydroxy-3-allyl oxypropyl ester derivative thereof.
23. A co-polymer as claimed in any one of claims 17 to 21 having two different types of functional groups and one type of functional group contains hydroxyl groups and the other contains carboxyl groups or hydroxyl and blocked



isocyanate groups, hydroxyl and epoxy groups or carboxyl groups or salts thereof and allyl or 2-hydroxy-3-allyl oxypropyl ester groups.

- 5 24. A co-polymer as claimed in any one of claims 17 to 23 and comprising an auxilliary functional unit containing a wetting group.
25. A co-polymer as claimed in claim 24 where the substituent in the functional group is other than isocyanate and the wetting group is 4-nitro or 4-amino benzoyl ester.
- 10 26. A co-polymer as claimed in any one of claims 17 to 25 where the total average mole percentage of functional and auxilliary functional units in each arm is 0.5 to 5 mole %.
27. A co-polymer as claimed in any one of claims 17 to 22 where the functional units are derived from allyl alcohol or glycidyl methacrylate or acrylate and methacrylate esters of formula (3);

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where R<sup>1</sup> is hydrogen or methyl and R<sup>2</sup> is C<sub>2-6</sub> alkane diyl.

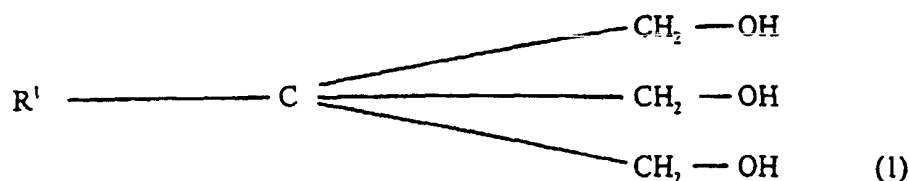
28. A co-polymer as claimed in claim 27 where R<sup>2</sup> is butane-1,4-diyl and R<sup>1</sup> is hydrogen or R<sup>1</sup> is methyl and R<sup>2</sup> is ethane-1,2-diyl.
- 25 29. A co-polymer as claimed in any one of claims 17 to 28 where the structural units are units derived from C<sub>1-8</sub> alkyl esters of acrylic or methacrylic acids, vinyl C<sub>2-6</sub> alkanoates and styrene and its C<sub>1-4</sub> alkyl analogues.
30. A co-polymer as claimed in claim 29 where the structural units are derived from methyl methacrylate, ethyl methacrylate, butyl methacrylate and butyl acrylate.
- 30 31. A coating composition comprising a co-polymer as claimed in any one of claims 17 to 30 and a liquid diluent or carrier.
32. A process for coating an object which comprises applying to the surface of the object a film of co-polymer as claimed in any one of claims 17 to 30 and allowing the polymer film to crosslink.

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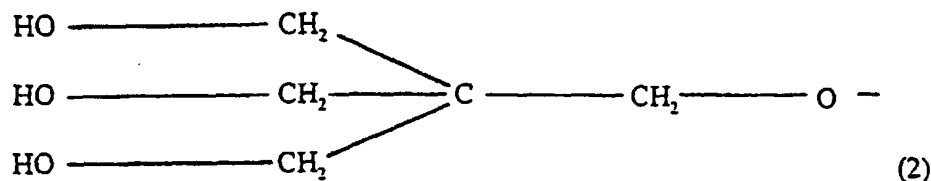
#### Patentansprüche

- 40 1. Eine vernetzbare Beschichtungszusammensetzung, die ein Stern-Copolymer und einen flüssigen Verdünner oder Träger umfaßt, dadurch gekennzeichnet, daß das Stern-Copolymer ein Zentrum aufweist, von dem 3 bis 8 Arme strahlenförmig ausgehen, bei dem das Zentrum der Rest eines trifunktionellen bis oktafunktionellen Thiolesters ist, der aus einem trifunktionellen bis oktafunktionellen Alkohol und einer Thio-C<sub>2-6</sub>-alkansäure gebildet wird, und bei dem jeder Arm ein Additionspolymer ist, das strukturelle Einheiten und funktionelle Einheiten aufweist, wobei die funktionellen Einheiten, nicht aber die strukturellen Einheiten, Vernetzungssubstituenten aufweisen und ge-
- 45 genseitig verträglich sind, so daß die Vernetzungssubstituenten eine Vernetzungsreaktion mit entweder einem Vernetzungsmittel, wobei in diesem Fall die Zusammensetzung auch ein Vernetzungsmittel umfaßt, oder mit dem gleichen oder einem komplementären Substituenten in funktionellen Einheiten in einem anderen Molekül des gleichen Polymers eingehen können, und gegebenenfalls verträgliche funktionelle Hilfseinheiten, die Vernetzungsgruppen enthalten.
- 50 2. Beschichtungszusammensetzung nach Anspruch 1, wobei das Copolymer ein gewichtsmittleres Gesamtmolekulargewicht von 3 000 bis einschließlich 30 000 hat.
3. Beschichtungszusammensetzung nach Anspruch 1 oder 2, wobei das Copolymer 3, 4 oder 6 Arme hat.
- 55 4. Beschichtungszusammensetzung nach Anspruch 3, wobei das Copolymer 4 oder 6 Arme hat.

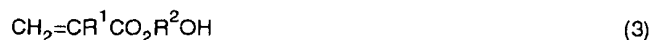
5. Beschichtungszusammensetzung nach irgendeinem der Ansprüche 1 bis 4, wobei der Alkohol, aus dem der Thiolester gebildet wird, die Formel (1) hat;



in der R<sup>1</sup> für Wasserstoff, C<sub>1-4</sub> Alkyl, Hydroxy-C<sub>1-4</sub>-alkyl oder eine Gruppe mit Formel (2) steht;



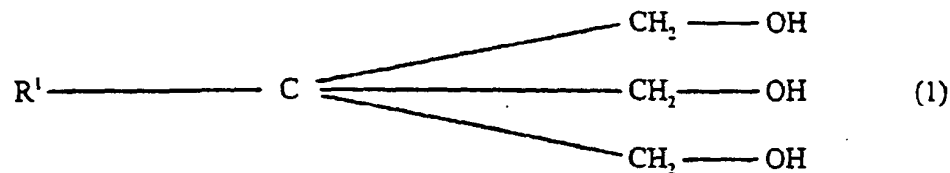
6. Beschichtungszusammensetzung nach irgendeinem der Ansprüche 1 bis 5, wobei die Thio-C<sub>2-6</sub>-alkansäure 2-Mercaptoessig- oder 3-Mercaptopropionsäure ist.
7. Beschichtungszusammensetzung nach irgendeinem der Ansprüche 1 bis 6, wobei sämtliche funktionelle Einheiten den gleichen Vernetzungsubstituenten enthalten und der Substituent eine Hydroxyl-Gruppe, eine Isocyanat-Gruppe, eine Epoxy-Gruppe, eine Carboxy-Gruppe oder ein Salz davon oder ein Allyl- oder 2-Hydroxy-3-allyloxypropylester-Derivat davon ist.
8. Beschichtungszusammensetzung nach irgendeinem der Ansprüche 1 bis 6 mit zwei verschiedenen Typen funktioneller Gruppen, wobei ein Typ der funktionellen Gruppen Hydroxyl-Gruppen enthält und der andere Carboxyl-Gruppen oder Hydroxyl- und blockierte Isocyanat-Gruppen, Hydroxyl- und Epoxy-Gruppen oder Carboxyl-Gruppen oder Salze davon und Allyl- oder 2-Hydroxy-3-allyloxypropylester-Gruppen enthält.
9. Beschichtungszusammensetzung nach irgendeinem der Ansprüche 1 bis 8, die eine funktionelle Hilfseinheit aufweist, die eine Benetzungsgruppe enthält.
10. Beschichtungszusammensetzung nach Anspruch 9, wobei der Substituent in der funktionellen Gruppe ein anderer als Isocyanat ist und die Benetzungsgruppe 4-Nitro- oder 4-Aminobenzoyl-ester ist.
11. Beschichtungszusammensetzung nach irgendeinem der Ansprüche 1 bis 10, wobei der mittlere Mol-Gesamtprozentsatz an funktionellen Einheiten und funktionellen Hilfseinheiten in jedem Arm 0,5 bis 5 Mol-% beträgt.
12. Beschichtungszusammensetzung nach irgendeinem der Ansprüche 1 bis 7, wobei die funktionellen Einheiten von Allylalkohol oder Glycidylmethacrylat oder Acrylat- und Methacrylatestern mit der Formel (3) stammen;



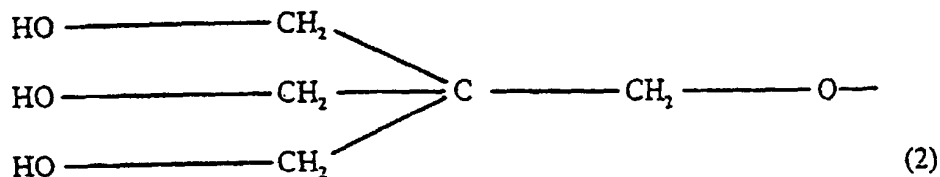
in der

R<sup>1</sup> für Wasserstoff oder Methyl steht und  
R<sup>2</sup> für C<sub>2-6</sub>-Alkandiyol steht.

13. Beschichtungszusammensetzung nach Anspruch 12, wobei R<sup>2</sup> für Butan-1,4-diyl und R<sup>1</sup> für Wasserstoff steht oder R<sup>1</sup> für Methyl und R<sup>2</sup> für Ethan -1,2-diyl steht.
14. Beschichtungszusammensetzung nach irgendeinem der Ansprüche 1 bis 13, wobei die strukturellen Einheiten Einheiten sind, die von C<sub>1-8</sub>-Alkylestern von Acryl- oder Methacrylsäure, Vinyl-C<sub>2-6</sub>-alkanoaten und Styrol und seinen C<sub>1-4</sub>-Alkyl-Analogen stammen.
15. Beschichtungszusammensetzung nach Anspruch 14, wobei die strukturellen Einheiten von Methylmethacrylat, Ethylmethacrylat, Butylmethacrylat und Butylacrylat stammen.
16. Verfahren zum Beschichten eines Gegenstandes, daß das Auftragen eines Films einer Beschichtungszusammensetzung nach irgendeinem der Ansprüche 1 bis 15 auf die Oberfläche des Gegenstandes umfaßt und dem Polymerfilm ermöglicht, sich zu vernetzen.
17. Stern-Copolymer mit einem gewichtsmittleren Gesamtmolekulargewicht von 3 000 bis einschließlich 30 000, das ein Zentrum aufweist, von dem 3 bis 8 Arme strahlenförmig ausgehen, bei dem das Zentrum der Rest eines trifunktionellen bis oktafunktionellen Thioesters ist, der aus einem trifunktionellen bis oktafunktionellen Alkohol und einer Thio-C<sub>2-6</sub>-alkansäure gebildet wird, und bei dem jeder Arm ein Additionspolymer ist, das strukturelle Einheiten und funktionelle Einheiten umfaßt, wobei die funktionellen Einheiten, nicht aber die strukturellen Einheiten, Vernetzungssubstituenten aufweisen und gegenseitig verträglich sind, so daß die Vernetzungssubstituenten eine Vernetzungsreaktion mit einem Vernetzungsmittel oder mit dem gleichen oder einem komplementären Substituenten in funktionellen Einheiten in einem anderen Molekül des gleichen Polymers eingehen können, und gegebenenfalls verträgliche funktionelle Hilfseinheiten, die Benetzungsgruppen enthalten.
18. Copolymer nach Anspruch 17, wobei das Copolymer 3, 4 oder 6 Arme hat.
19. Copolymer nach Anspruch 18, wobei das Copolymer 4 oder 6 Arme hat.
20. Copolymer nach irgendeinem der Ansprüche 17 bis 19, wobei der Alkohol, aus dem der Thioester gebildet wird, die Formel (1) hat;



in der R<sup>1</sup> für Wasserstoff, C<sub>1-4</sub>-Alkyl, Hydroxy-C<sub>1-4</sub>-alkyl oder eine Gruppe mit der Formel (2) steht;



21. Copolymer nach irgendeinem der Ansprüche 17 bis 20, wobei die Thio-C<sub>2-6</sub>-alkansäure 2-Mercaptoessig- oder 3-Mercaptopropionsäure ist.
22. Copolymer nach irgendeinem der Ansprüche 17 bis 21, wobei sämtliche funktionelle Einheiten den gleichen Vernetzungssubstituent enthalten und der Substituent eine Hydroxylgruppe, eine Isocyanat-Gruppe, eine Epoxy-Gruppe, eine Carboxyl-Gruppe oder ein Salz davon oder ein Allyl- oder 2-Hydroxy-3-allyloxypropylester-Derivat

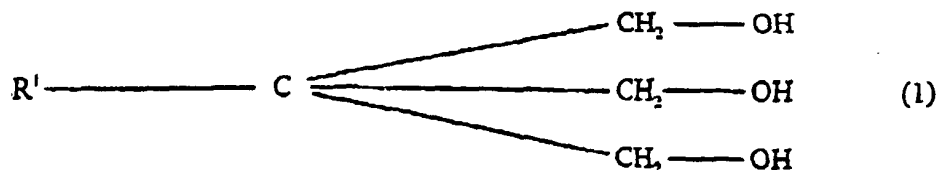
davon ist.

23. Copolymer nach irgendeinem der Ansprüche 17 bis 21 mit zwei verschiedenen Typen funktioneller Gruppen, wobei ein Typ der funktionellen Gruppen Hydroxyl-Gruppen enthält und der andere Carboxyl-Gruppen oder Hydroxyl- und blockierte Isocyanat-Gruppen, Hydroxyl- und Epoxy-Gruppen oder Carboxyl-Gruppen oder Salze davon und Allyl- oder 2-Hydroxy-3-allyloxypropylester-Gruppen enthält.
24. Copolymer nach irgendeinem der Ansprüche 17 bis 23, das eine funktionelle Hilfseinheit umfaßt, die eine Benetzungsgruppe enthält.
25. Copolymer nach Anspruch 24, wobei der Substituent der funktionellen Gruppe ein anderer als Isocyanat ist und die Benetzungsgruppe 4-Nitro- oder 4-Aminobenzoyl-ester ist.
26. Copolymer nach irgendeinem der Ansprüche 17 bis 25, wobei der mittlere Mol-Gesamtprozentatz an funktionellen Einheiten und funktionellen Hilfseinheiten in jedem Arm 0,5 bis 5 Mol-% beträgt.
27. Copolymer nach irgendeinem der Ansprüche 17 bis 22, wobei die funktionellen Einheiten von Allylalkohol oder Glycidyl-Methacrylat oder Acrylat- und Methacrylatestern mit der Formel (3) stammen;
- $$\text{CH}_2=\text{CR}^1\text{CO}_2\text{R}^2\text{OH} \quad (3)$$
- in der  $\text{R}^1$  für Wasserstoff oder Methyl steht und  $\text{R}^2$  für  $\text{C}_{2-6}$ -Alkandiyol steht.
28. Copolymer nach Anspruch 27, wobei  $\text{R}^2$  für Butan-1,4-diyl und  $\text{R}^1$  für Wasserstoff steht oder  $\text{R}^1$  für Methyl und  $\text{R}^2$  für Ethan-1,2-diyl steht.
29. Copolymer nach irgendeinem der Ansprüche 17 bis 28, wobei die strukturellen Einheiten Einheiten sind, die von  $\text{C}_{1-8}$ -Alkylestern von Acryl- oder Methacrylsäure, Vinyl- $\text{C}_{2-6}$ -alkanoaten und Styrol und seinen  $\text{C}_{1-4}$ -Alkyl-Analogen stammen.
30. Copolymer nach Anspruch 29, wobei die strukturellen Einheiten von Methylmethacrylat, Ethylmethacrylat, Butylmethacrylat und Butylacrylat stammen.
31. Beschichtungszusammensetzung, die ein Copolymer nach irgendeinem der Ansprüche 17 bis 30 und einen flüssigen Verdünner oder Träger umfaßt.
32. Verfahren zum Beschichten eines Gegenstandes, daß das Auftragen eines Films eines Copolymers nach irgendeinem der Ansprüche 17 bis 30 auf die Oberfläche des Gegenstands umfaßt und den Polymerfilm ermöglicht, sich zu vernetzen.

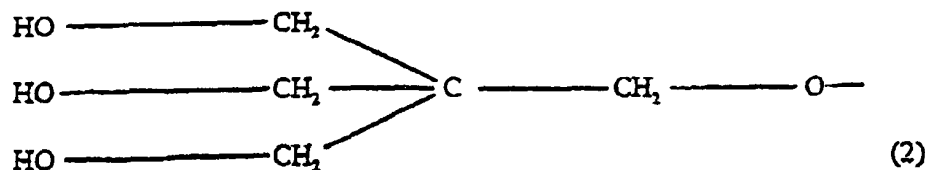
## Revendications

1. Composition de revêtement réticulable, comprenant un copolymère en étoile et un diluant ou véhicule liquide, caractérisée en ce que le copolymère en étoile a une portion centrale de laquelle rayonnent 3 à 8 bras, la portion centrale étant le résidu d'un thiol-ester trifonctionnel à octafonctionnel, formé à partir d'un alcool trifonctionnel à octafonctionnel et d'un acide thio-alcanoïque en  $\text{C}_2$  à  $\text{C}_6$ , et chaque bras étant un polymère d'addition comprenant des motifs structuraux et des motifs fonctionnels, dans lequel les motifs fonctionnels, mais non les motifs structuraux, comprennent des substituants de réticulation et sont mutuellement compatibles en ce que les substituants de réticulation sont capables de subir une réaction de réticulation, avec soit un agent de réticulation, auquel cas la composition comprend également un agent de réticulation, soit le même substituant ou un substituant complémentaire dans des motifs fonctionnels dans une autre molécule du même polymère, et facultativement des motifs fonctionnels auxiliaires compatibles qui contiennent des groupes mouillants.
2. Composition de revêtement suivant la revendication 1, dans laquelle le copolymère a une moyenne pondérale totale du poids moléculaire de 3000 à 30 000 inclus.

3. Composition de revêtement suivant la revendication 1 ou la revendication 2, dans laquelle le copolymère a 3, 4 ou 6 bras.
4. Composition de revêtement suivant la revendication 3, dans laquelle le copolymère a 4 ou 6 bras.
5. Composition de revêtement suivant l'une quelconque des revendications 1 à 4, dans laquelle l'alcool, à partir duquel le thiol-ester est formé, répond à la formule (1) :



dans laquelle R' représente l'hydrogène, un groupe alkyle en C<sub>1</sub> à C<sub>4</sub>, hydroxyalkyle en C<sub>1</sub> à C<sub>4</sub>, ou un groupe de formule (2) :

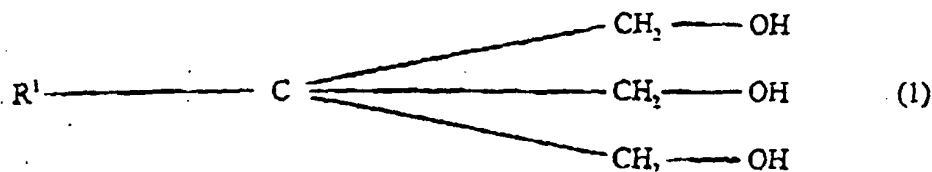


6. Composition de revêtement suivant l'une quelconque des revendications 1 à 5, dans laquelle l'acide thio-alcanolique en C<sub>2</sub> à C<sub>6</sub> est l'acide 2-mercapto-acétique ou 3-mercaptopropionique.
7. Composition de revêtement suivant l'une quelconque des revendications 1 à 6, dans laquelle les motifs fonctionnels contiennent tous le même substituant de réticulation, et le substituant est un groupe hydroxyle, un groupe isocyanate, un groupe époxy, un groupe carboxy ou un de ses sels ou bien un de ses dérivés du type ester allylique ou 2-hydroxy-3-allyloxypropylique.
8. Composition de revêtement suivant l'une quelconque des revendications 1 à 6, ayant deux types différents de groupes fonctionnels, un type de groupe fonctionnel contenant des groupes hydroxyle et l'autre contenant des groupes carboxyle ou des groupes hydroxyle et des groupes isocyanate bloqués, des groupes hydroxyle et des groupes époxy ou des groupes carboxyle ou bien leurs sels et des groupes ester allylique ou 2-hydroxy-3-allyloxypropylique.
9. Composition de revêtement suivant l'une quelconque des revendications 1 à 8, qui comprend un motif fonctionnel auxiliaire contenant un groupe mouillant.
10. Composition de revêtement suivant la revendication 9, dans laquelle le substituant dans le groupe fonctionnel est autre qu'un substituant isocyanate et le groupe mouillant est un groupe ester de 4-nitro- ou 4-aminobenzoyle.
11. Composition de revêtement suivant l'une quelconque des revendications 1 à 10, dans laquelle le pourcentage molaire moyen total des motifs fonctionnels et des motifs fonctionnels auxiliaires dans chaque bras va de 0,5 à 5 moles %.
12. Composition de revêtement suivant l'une quelconque des revendications 1 à 7, dans laquelle les motifs fonctionnels sont dérivés de l'alcool allylique ou du méthacrylate de glycidyle ou d'esters acryliques et méthacryliques de formule (3) :

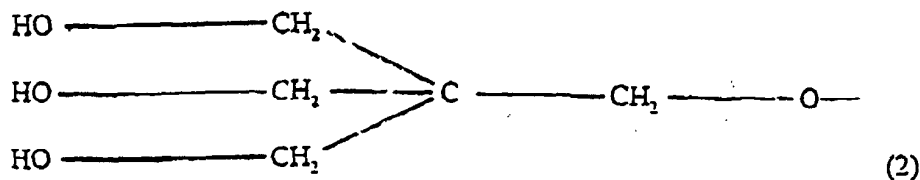


dans laquelle  $\text{R}^1$  représente l'hydrogène ou un groupe méthyle, et  $\text{R}^2$  représente un groupe alcanediyle en  $\text{C}_2$  à  $\text{C}_6$ .

13. Composition de revêtement suivant la revendication 12, dans laquelle  $\text{R}^2$  représente un groupe butane-1,4-diyle et  $\text{R}^1$  représente l'hydrogène, ou bien  $\text{R}^1$  représente un groupe méthyle et  $\text{R}^2$  représente un groupe éthane-1,2-diyle.
14. Composition de revêtement suivant l'une quelconque des revendications 1 à 13, dans laquelle les motifs structuraux sont des motifs dérivés d'esters d'alkyle en  $\text{C}_1$  à  $\text{C}_8$  d'acide acrylique ou méthacrylique, d'alcanoates (en  $\text{C}_2$  à  $\text{C}_6$ ) de vinyle et du styrène et de ses analogues à substituants alkyle en  $\text{C}_1$  à  $\text{C}_4$ .
15. Composition de revêtement suivant la revendication 14, dans laquelle les motifs structuraux sont dérivés du méthacrylate de méthyle, du méthacrylate d'éthyle, du méthacrylate de butyle et de l'acrylate de butyle.
16. Procédé pour le revêtement d'un objet, qui comprend les étapes consistant à appliquer à la surface de l'objet un film d'une composition de revêtement suivant l'une quelconque des revendications 1 à 15, et à laisser le film polymérique subir une réticulation.
17. Copolymère en étoile ayant une moyenne pondérale du poids moléculaire de 3000 à 30 000 inclus comportant une portion centrale de laquelle rayonnent 3 à 8 bras, ladite portion centrale étant le résidu d'un thiol-ester trifonctionnel à octafonctionnel, formé à partir d'un alcool trifonctionnel à octafonctionnel et d'un acide thioalcanoïque en  $\text{C}_2$  à  $\text{C}_6$ , et chaque bras étant constitué d'un polymère d'addition comprenant des motifs structuraux et des motifs fonctionnels, lesdits motifs fonctionnels mais non les motifs structuraux, comprenant des substituants de réticulation et étant mutuellement compatibles en ce que les substituants de réticulation sont capables de subir une réaction de réticulation avec un agent de réticulation ou bien le même substituant ou un substituant complémentaire dans des motifs fonctionnels dans une autre molécule du même polymère, et facultativement des motifs fonctionnels auxiliaires compatibles qui contiennent des groupes mouillants.
18. Copolymère suivant la revendication 17, qui a 3, 4 ou 6 bras.
19. Copolymère suivant la revendication 18, qui a 4 ou 6 bras.
20. Copolymère suivant l'une quelconque des revendications 17 à 19, dans lequel l'alcool à partir duquel le thiol-ester est formé répond à la formule (1)



dans laquelle  $\text{R}^1$  représente l'hydrogène, un groupe alkyle en  $\text{C}_1$  à  $\text{C}_4$ , un groupe hydroxyalkyle en  $\text{C}_1$  à  $\text{C}_4$  ou un groupe de formule (2) :



21. Copolymère suivant l'une quelconque des revendications 17 à 20, l'acide thio-alcanoïque en C<sub>2</sub> à C<sub>6</sub> étant l'acide 2-mercapto-acétique ou l'acide 3-mercaptopropionique.
- 5 22. Copolymère suivant l'une quelconque des revendications 17 à 21, dans lequel les motifs fonctionnels contiennent tous le même substituant de réticulation et le substituant est un groupe hydroxyle, un groupe isocyanate, un groupe époxy, un groupe carboxy ou un de ses sels ou un de ses dérivés du type ester allylique ou 2-hydroxy-3-allyloxy-propylique.
- 10 23. Copolymère suivant l'une quelconque des revendications 17 à 21, comprenant deux types différents de groupes fonctionnels, et un type de groupe fonctionnel contenant des groupes hydroxyle et l'autre contenant des groupes carboxyle ou hydroxyle et des groupes isocyanate bloqués, des groupes hydroxyle et époxy ou des groupes carboxyle ou leurs sels et des groupes ester allylique ou 2-hydroxy-3-allyloxypropylique.
- 15 24. Copolymère suivant l'une quelconque des revendications 17 à 23, comprenant un motif fonctionnel auxiliaire contenant un groupe mouillant.
- 25 25. Copolymère suivant la revendication 24, dans lequel le substituant dans le groupe fonctionnel est autre qu'un substituant isocyanate et le groupe mouillant consiste en ester de 4-nitro- ou 4-amino-benzoyle.
- 20 26. Copolymère suivant l'une quelconque des revendications 17 à 25, dans lequel le pourcentage molaire moyen total de motifs fonctionnels et motifs fonctionnels auxiliaires dans chaque bras est compris dans l'intervalle de 0,5 à 5 moles %.
- 25 27. Copolymère suivant l'une quelconque des revendications 17 à 22, dans lequel les motifs fonctionnels sont dérivés de l'alcool allylique ou du méthacrylate ou acrylate de glycidyle et d'esters consistant en méthacrylates de formule (3) :
- $$\text{CH}_2 = \text{CR}^1 \text{CO}_2 \text{R}^2 \text{OH} \quad (3)$$
- 30 dans laquelle R<sup>1</sup> représente l'hydrogène ou un groupe méthyle et R<sup>2</sup> représente un groupe alcanediyle en C<sub>2</sub> à C<sub>6</sub>.
- 35 28. Copolymère suivant la revendication 27, dans lequel R<sup>2</sup> représente un groupe butane-1,4-diyle et R<sup>1</sup> représente l'hydrogène, ou bien R<sup>1</sup> représente un groupe méthyle et R<sup>2</sup> représente un groupe éthane-1,2-diyle.
- 40 29. Copolymère suivant l'une quelconque des revendications 17 à 28, dans lequel les motifs structuraux sont des motifs dérivés d'esters d'alkyle en C<sub>1</sub> à C<sub>8</sub> d'acide acrylique ou d'acide méthacrylique, d'alcanoates en C<sub>2</sub> à C<sub>6</sub> de vinyle et du styrène et de ses analogues alkylés en C<sub>1</sub> à C<sub>4</sub>.
- 45 30. Copolymère suivant la revendication 29, dans lequel les motifs structuraux sont dérivés du méthacrylate de méthyle, du méthacrylate d'éthyle, du méthacrylate de butyle et de l'acrylate de butyle.
- 50 31. Composition de revêtement comprenant un copolymère suivant l'une quelconque des revendications 17 à 30 et un diluant ou véhicule liquide.
- 55 32. Procédé pour le revêtement d'un objet, qui comprend les étapes consistant à appliquer à la surface de l'objet un film d'un copolymère suivant l'une quelconque des revendications 17 à 30 et à laisser le film de polymère subir une réticulation.